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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

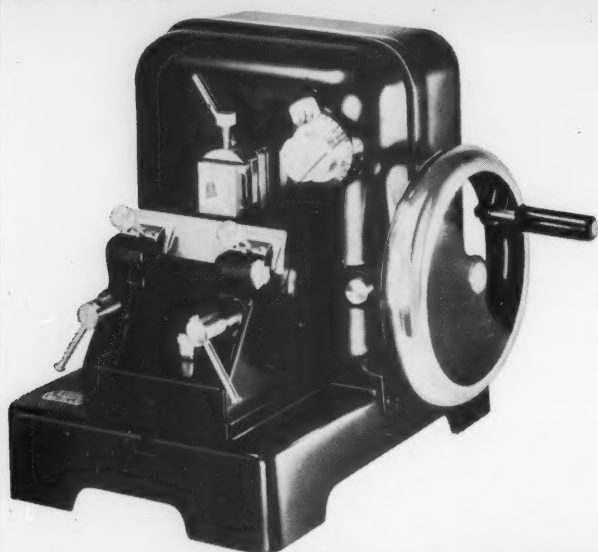
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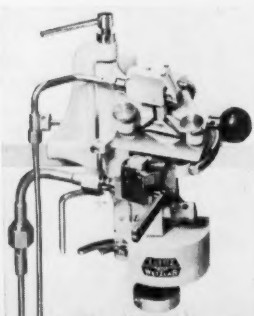
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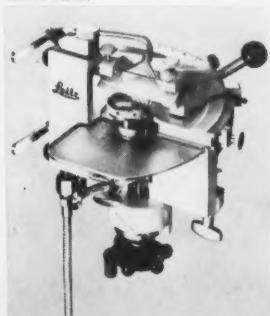
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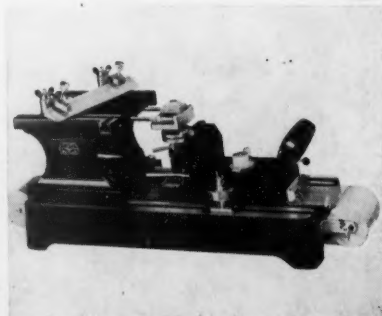
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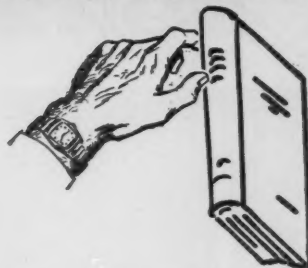
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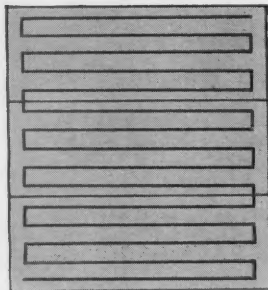
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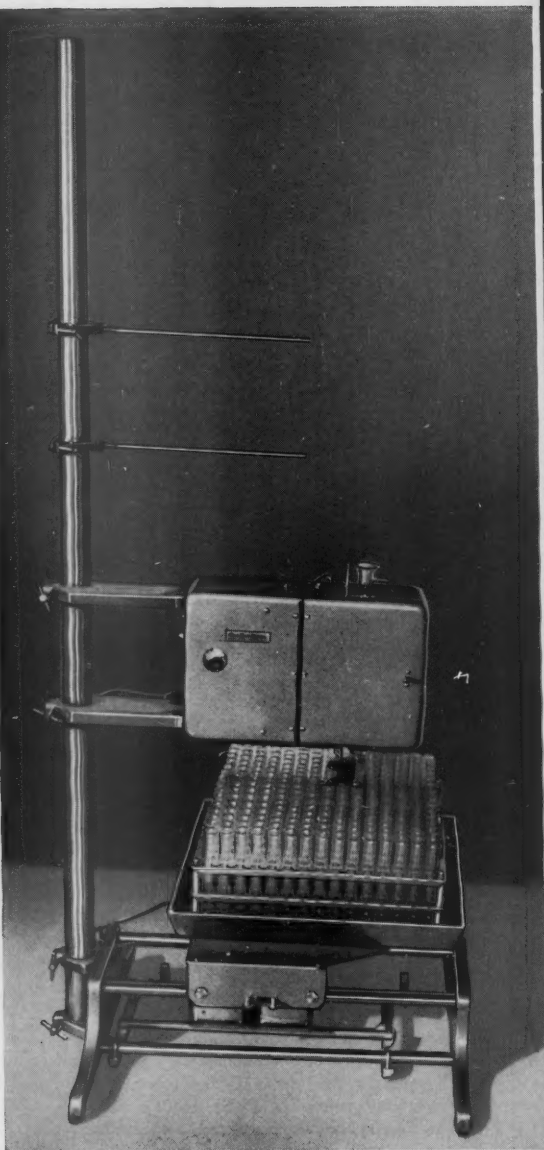


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Cover	Luminescence at micro concentrations of the enzyme-substrate system ("luciferase-luciferin" system) of the ostracod crustacean <i>Cypridina</i> (0.14 μ M luciferin and 1.2 μ M luciferase in the flask). In the foreground, specimens are luminescing after storage for 2 months with Dry Ice. See page 1755. [F. H. Johnson, Princeton University]	

APPLICATION FOR HOTEL RESERVATIONS

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Denver, 26-31 December 1961

The hotels for the AAAS Denver meeting have established special, low rates and have reserved appropriately large blocks of rooms for this meeting. Thus everyone making room reservations for the AAAS meeting is assured substantial savings.

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For a list of the headquarters of each participating society and section, see page 197, *Science*, 21 July. The Hilton is the AAAS headquarters hotel.

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Studies in the Magnetic Properties of Thin Metallic Films

Temporary or transient memories of electronic computers consist of small doughnut-shaped ferrite cores hand-assembled into many complex matrices. Bulk, speed of response and costly manufacture create inherent limitations. It now appears possible to overcome these by replacing ferrite cores with tiny spots of magnetic film vapor deposited on a smooth flat surface.

Today's electronic computer has a memory which is part of the brain of the machine. Larger machines commonly have two memories: one for permanent storage of information, the other for temporary storage of more transient information. The temporary memory consists of a collection of ferrite cores, each core shaped like a tiny doughnut and having a number of wires laced between it and other cores forming a matrix or grid. The wires carry either the pulse of electricity which magnetizes the core, or a similar pulse which is the core's response to interrogation.

A series of these pulses, handled in a binary number system, have become the language of the computer. To function binumerically, circuits represent "0" by not conducting current, and represent "1" by conducting. Each memory core can be magnetized in one direction for "0", the opposite direction for "1." To avoid ambiguities, cores are made so they are not readily magnetized in any direction other than these two.

Each small ferrite core can be magnetized or interrogated in about a micro-second (one-millionth second). Unfortunately, the assembly of ferrite cores discourages automation processes, making manufacture slow and costly. In addition, the tremendous bulk of many millions of cores properly assembled prohibits machines requiring considerably larger transient memories.

Current basic research indicates that one of the most promising successors to the ferrite core is a tiny spot of magnetic film about 1,000 Angstroms (four millionths of an inch) thick, deposited on a

smooth flat surface. These films have been prepared in Honeywell's Research Laboratories from an alloy of nickel and iron by heating the alloy until it vaporizes in a vacuum. Each freed vapor particle travels until it strikes a cooler surface. There it condenses and stays, if the surface is suitable and immaculately clean.

It might be assumed that the task would be simple. However, as the vapor condenses and becomes solid, it seems to become peculiarly sensitive to the nature of the surface on which it is being deposited. Unless oriented by a magnetic field (created by large coils that encircle the vacuum chamber), the films could be magnetized in a number of directions instead of along the desired single line. When we obtain uniformly bi-stable spots, we are in effect duplicating the action of ferrite cores. We also may use the same cycle by which bits of information are stored and extracted by reversing direction of the magnetic field.

The coercive force necessary to reverse (or "flip") the direction of magnetization within a thin film is very low. Another important advantage stems from the fact that reversal may be accomplished either by employing a rotational mechanism (simultaneous rotation of all atomic magnetic moments) or a wall-motion mechanism (sequential rotation of the atomic magnetic moments in the form of a moving wall). Both may be induced through application of a coercive force as small as one Oersted. Of the two mechanisms, rotational is much the faster; it makes possible the reading and writing of 100,000,000 bits of information per second

on a single spot, as compared to about 100,000 for ferrite cores.

Honeywell scientists have consistently produced 256 bit (16x16) matrices uniform to plus or minus 5% of energy. Only this uniformity makes it possible to use the films in circuits, since a given small electrical pulse applied to any film must flip that film.

Uniformity has been achieved in part through study of deposition techniques and experiments both with various types of substrata and with various methods of cleaning them before deposition. It has resulted also, through broader understanding of the mechanisms involved, in causing reversal of the magnetic field. Even more important, however, have been detailed investigations into the factors that lead to non-uniformity, and subsequent development of techniques that tend to eliminate them.

The most difficult task remaining seems to be linking the film spots with printed circuits which will probably replace the wires used with the ferrite cores.

Our research on thin films is both basic and applied. Applied, since our scientists are trying to create better, faster, smaller memory systems for the commercial and military computers our engineers design; and basic, since they are trying to understand and explain all the phenomena described, as well as others that are completely baffling.

If you are engaged in magnetics research and would like to know more about Honeywell's work on thin magnetic films, you're invited to correspond with Dr. Richard Prosen, Honeywell Research Center, Hopkins, Minnesota. Or, if you would like a simplified explanation of the binary number system and how to perform standard mathematical manipulations using this system, write to Honeywell Research, Minneapolis 8, Minnesota.

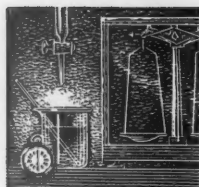
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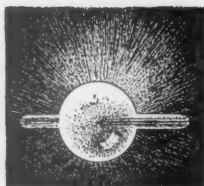
IT HAPPENED THIS MONTH...

a glance at yesterday in relation to today



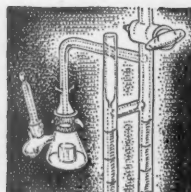
IN DECEMBER—(1905)—A preliminary communication to the Chemical Society (London) discusses a method of estimating tyrosine by bromination and the use of this estimate as a measure of proteolytic activity. Tyrosine is reported to be an early product of tryptic hydrolysis, all the tyrosine in a protein being liberated during the first stage of tryptic digestion. Resistance of the protein tyrosine nucleus to peptic hydrolysis is confirmed. This appears to offer a trustworthy method of differentiating peptic from tryptic enzymes.¹

Colorimetric and spectrophotometric methods of tyrosine determination are still widely used for the assay of extracellular tryptic activity. However, there is still no reliable method for measuring intracellular protein breakdown. If you are working in this area—or in the related and very active field of protein biosynthesis—Schwarz has a wide variety of biochemicals which you will find useful. These include optically standardized natural amino acids—many of them labeled with C^{14} , H^3 , S^{35} , N^{15} and O^{18} ; peptides and polyamino acids; ribonucleosides-5'-triphosphates for RNA synthesis, radiolabeled or isotopically stable, as you wish.



IN DECEMBER—(1934)—*Science*² reviews some of the year's important advances in physics and chemistry. By bombarding boron, magnesium, and aluminum with alpha particles, F. Joliot and Irene Curie-Joliot created artificial radioactivity for the first time. They predict the development of new radioisotopes useful in medicine. Triple-weight hydrogen, three times as heavy as the ordinary kind, was discovered by Rutherford, Oliphant, and Hartek at Cambridge; Tuve, Hafstad, and Dahl at the Carnegie Institute; and Harnwell, Smyth, Bleakney, and Smith at Princeton.

The prediction of the Joliot's has become an impressive reality; tracer techniques have since become essential for biological and medical research. Schwarz supplies tritiated ribo- and deoxyribonucleotides and tritiated-L-histidine, tyrosine, and proline—the only optically pure tritiated L-amino acids commercially available. Our tritiated thymidine contains 6.25 curies/mole, the highest specific activity obtainable anywhere.



IN DECEMBER—(1954)—Brawerman and Chargaff³ report some studies on malt, liver, and prostate nucleoside phosphotransferases (enzymes which transfer organically esterified phosphate to nucleosides). The prostate enzyme differentiates between ribo- and deoxyribosides, the liver enzyme between uracil and cytosine ribosides. The malt enzyme accepts phosphate from many nucleotides and may function as a catalyst for nucleotide interconversion—a role analogous to that of the transaminases in amino acid metabolism.

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1. Brown, A. J., and Millar, E. T.: The liberation of tyrosine during tryptic proteolysis. A preliminary communication. *Proc. Chem. Soc. (London)* 21:286 (Dec. 15) 1905. 2. *Science News: Science* 80:6 (Dec. 21) 1934. 3. Brawerman, G., and Chargaff, E.: On the synthesis of nucleotides by nucleoside phosphotransferases. *Biochim. et Biophys. Acta* 15:349 (Dec.) 1954.



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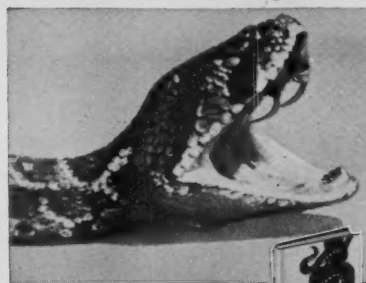
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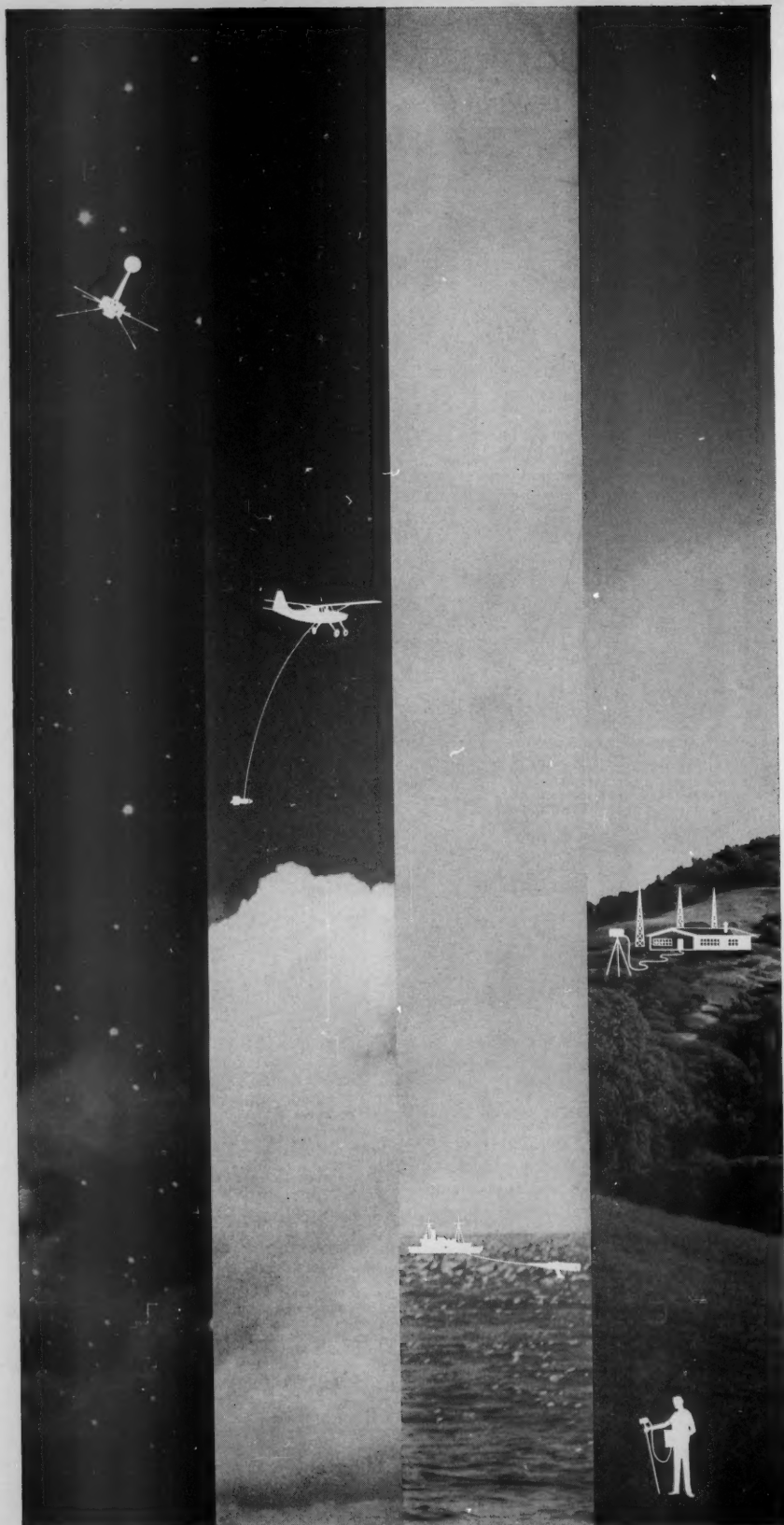
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Means and Ends

Our nation has long been committed to the proposition that education is both a private and a public good: that it benefits the individual by making him a more fully developed human being and by increasing his earning power and that it benefits the country by producing the skills and understanding that make a complex industrial democracy possible.

State and local governments have assumed the task of providing free high school education for all. But in higher education, recognition of public responsibility has not gone so far. Governments at all levels grant tax exemption to private institutions, and both state and local governments support universities and junior colleges at which the students typically pay tuition to cover a part of the educational costs.

The federal government made its first land grants to states for the support of education, including higher education, in 1787, and with the Morrill acts of 1862 and 1890 it greatly enlarged this support. Since then, the federal government has had an increasingly important effect on higher education, through loans to students, fellowships for graduate study (especially in the sciences), and contracts and grants for research and development.

The most important educational policy question for the 1960's is how to meet the coming crisis in higher education. That a crisis is on the way, no one can doubt. The number of students of college age (18 through 21) is increasing, as is the percentage of students who go to college. A study by Alice M. Rivlin, "The Role of the Federal Government in Financing Higher Education" (Brookings Institution, 1961), brings together the figures. In 1960 the number in the college age group was 9.6 million; by 1970 the number will be an estimated 14.6 million. The percentage of the college age group enrolled in college has increased more than ninefold since the turn of the century: 4 percent in 1900; 15 percent in 1940; and 38 percent in 1960. The percentage may rise to 50 in 1970. If it does, the number of students will go from the 3.7 million enrolled in 1960 to 7.6 million in 1970. If adequate facilities are to be constructed and if new faculty members are to be attracted in adequate numbers, costs will have to go up by more than a factor of 2.

How can the crisis be met? One proposal is to raise tuition sharply so that students would pay a larger share of the costs of their education. This would at the same time reduce the percentage of those who could go to college. Those opposed to this solution contend that higher fees would result in social injustice by depriving the economically underprivileged of equal opportunity for higher education and in a loss of potential talent that the country could ill afford from the standpoint either of economic growth or of national survival. Those who hold these views would resolve the debate, as Rivlin does, by urging a larger, but limited federal role: an expansion in the student loan program as carried out under the National Defense Education Act; provision of enough federal scholarships to assure that no bright but impecunious student would be barred from college for economic reasons; provision of federal funds for college buildings; and full payment of overhead costs for government-supported research and development projects.

The merit of these proposals is that they build on what is already in existence and that they neither imperil the freedom of the universities and colleges nor preclude the need for local public and private support.—G.DuS.



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CURRENT PROBLEMS IN RESEARCH

Senescence in
Plant Development

The death of plants or plant parts may be of positive ecological or physiological value.

A. C. Leopold

Of the steps in biological development, senescence is one of the least well defined. In the development of plants the stages of germination, flower initiation, fruit set, and maturation are relatively precise and are subject to relatively simple and concise measurement. Senescence, on the other hand, is a relatively gross change or series of changes, leading finally to the death of the plant. Alex Comfort (1), the animal physiologist, has described senescence as a decrease in viability with an increase in vulnerability. In plants we recognize these changes as decreases in growth rates and vigor and increases in susceptibility to challenge by the environment (through shortages of water, nutrients, or other physical comforts) or to challenges by pathogens or physical disturbance.

A characteristic consequence of senescence is the occurrence of death. The patterns of death curves—or, more euphemistically, of survivorship curves—for various biological populations can tell us a good deal about the senescence characteristics of the population. If a population of creatures dies off with a random mortality it will decline at a

constant rate. For example, if 50 percent die within one unit of time, 50 percent of the remainder within the next similar period, and so on, this population would not be exhibiting senescence, and the survivorship curve would have the form of curve *A* in Fig. 1. Many populations of animals and some plant populations exhibit such a survivorship curve, or one that is closely similar, either because the members of the population are removed by predatory activities or environmental forces faster than they are removed by the processes of senescence or because the population just does not have the physiological characteristic of senescence. A homely example of a population which shows essentially no senescence would be glass tumblers in a cafeteria (2). Any given tumbler is just as likely to be broken today as tomorrow, and the curve of survivorship for such a population may follow exactly curve *A* in Fig. 1.

The survivorship curve for an organism such as man takes the shape of curve *B* in Fig. 1, with a relatively low mortality rate until nearly the age of retirement and then a rapid decline in survivorship. Such a flexing curve, then, identifies a senescing population. This type of survivorship pattern is common to many animals, and again probably to many perennial plants. We can safely

assume that there are some internal biological mechanisms which bring about decline in viability and increase in vulnerability in such populations.

The extreme case of senescence would be one in which all the members of a population die at once and in unison as in the abrupt curve *C* in Fig. 1. This situation is essentially realized in nearly all annual species of plants. The sudden and synchronous death of literally millions of individuals of the same population is an ordinary sight in the wheat fields of the Plains states or the cornfields of the Midwest. The signal for mass hari-kari, so to speak, for all members of these enormous populations is such a fantastically dramatic physiological event that it seems most singular that plant physiologists have not given more attention to the matter. Surprisingly enough, this event in the life cycle of plants is not discussed in any of the current plant physiology texts.

Manifestations of Senescence

In animal species which display senescence there is a reasonable amount of evidence that, with aging, there may be a running out of the metabolic and developmental functions associated with youth. In fact, just recently Strehler and Mildvan (3) have presented an interesting analysis of statistical aspects of aging in animals to suggest that senescence may have such a physiological basis, with a progressive decline in many hormonal, enzymatic, and physiological functions leading to decreased viability and increased vulnerability of the organism. In the plant there are several expressions of senescence, including a variety of patterns of morphological deterioration and a characteristic subsidence of growth rates. Instead of a general running-out of the organism, there may be distinctive changes in the morphology, pigmentation, and internal nutrition pattern in the plant.

It may be helpful to try to recognize

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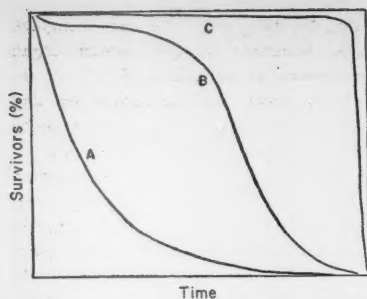


Fig. 1. Generalized survivorship curves for (A) populations which do not show senescence; (B) populations, such as man, which are more likely to die in the later years of their life-expectancy period; and (C) populations, such as annual plants, which die en masse at a rather specific time. The maximum life expectancy is plotted as the extreme right limit of the graph.

the morphological patterns of senescence in plants. There are obvious parallels between senescence of the entire plant and of the organs of the plant. Thus, for example, Fig. 2 illustrates in a diagrammatic way how some species of plants senesce as organisms, the entire individual dying in an abrupt, overall senescence, whereas in other species only individual organs senesce. The process in the latter species may involve the senescence of leaves and stems (top senescence, as in the case of perennial forbs), or it may involve the annual senescence of leaves only (deciduous senescence, as in the woody perennials), or it may involve only the progressive senescence of leaves from the base of the plant slowly up the stem. The ripening and deterioration of fruits is, of course, a generally occurring organ senescence. The point I want to make is that senescence may involve the entire organism or it may be limited to separate organs. The intergradations

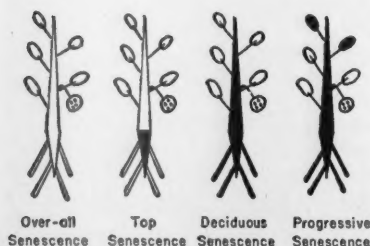


Fig. 2. Schematic representation of some types of senescence found in plants. Open areas, senescing parts; black areas (of leaves, stems, fruits, and roots), nonsenescing parts.

between organism senescence and organ senescence suggest that the same physiological signals may be involved, perhaps in varying degrees of intensity. There are, of course, many instances of single gene differences between species which are annuals and those which are perennial forbs or woody, deciduous plants, and the enticing possibility exists that these differences may be genetic differences in the intensities of the senescence signals.

The decrease in viability with senescence is evident not only in the occurrence of death but also in the subsidence of growth rate. Senescence in higher animals is not likely to be associated with a decline in growth rate, for the obvious reason that the animal essentially terminates its growth with adulthood. But the plant, having the essential form of a linear axis with meristems at each end, may grow continually and so is much more likely to reflect senescence in a changed growth rate. The sigmoid growth curve for organisms, for organs of the plant, or for individual cells is relevant to the observation of senescence. The growth curve for an oat plant, for example, follows this pattern, and the onset of the reproductive stages of flowering and fruiting are associated with a decline in and then termination of growth, followed by death of the whole plant. A somewhat analogous pattern is seen for each organ of the plant—for example, the sigmoid growth curve for each leaf up the stem, or the approximately sigmoid growth curve for each fruit, though the correlation of the growth curve with organ senescence is less impressive than the correlation with senescence of the whole plant, since leaves and fruits do not have the terminal meristem type of growth which the whole plant has.

Some further expressions of senescence are found in morphological and pigmentational changes in the plant or plant organs. As plants or their organs senesce there is frequently an associated increase in abscission, and leaves or fruits are shed from the plant. There is generally a major change in pigmentation, with loss of green color and development of the red or yellow colors of ripening fruits or falling leaves. These visible pigment changes are associated frequently with a respiratory peak or climacteric, both in fruits and in leaves (4), and with an exhaustive export of nutrients from the ripening leaves. The association of these catabolic functions with the senescence of

plants and plant organs suggests, again, the similarity of plant senescence and organ senescence. The frequent association of dormant or rest periods with most types of plant senescence (overall, top, or deciduous) is discussed in a later section.

Functions of Senescence

In zoological circles senescence is considered to have only negative values—those of sloughing off the older components of populations, limiting the size of the population, and removing, as in the case of man, the individuals with the most learning. The zoologist tells us that natural selection can probably serve only to restrict senescence to a section of the life cycle later than the reproductive phase, hence the frequent correlation of senescence with animal age groups past the reproductive period (1). Analogy between the botanical and zoological systems is dangerous here, however, for a little contemplation permits one to see that in many plants senescence has distinct and positive values, in terms of ecological adaptation, natural selection, and efficiency of internal physiology.

Discussion of the occurrence of senescence in various species as a seasonal function helps to illustrate its usefulness in ecological adaptation (Fig. 3). The annual march of the seasons is a timepiece to which the senescence of various species is attuned. The adaptation of many early spring species (such as tulips) to the earliest part of the growing season permits this species to grow freely, without the intense competition which occurs later in the season, and some species limit themselves to this season through the process of senescence—top senescence in the case of tulips. Other species are adapted to somewhat later parts of the growing season. Spring wheat, for example, is so adapted and terminates its growth through over-all senescence on about 1 July in the Midwest. Many species, such as soybean, straddle the middle of the growing season and senesce about 1 September; other species, such as corn, grow best in the warm temperatures of late summer and complete their life cycle just before frost in October. Illustrations could be as easily taken from wild species as from cultivated ones. The point to be made is that senescence may limit the growth of a plant species to a certain part of the

growing season. Far from having a negative function, here senescence may enable the species to adapt to environmental conditions such as seasons of cold, drought, or plant competition.

One can argue that the seasonal limitation is an adaptation of the species for a specific time of completion of the reproductive phases of growth instead of an adaptation for the time of senescence. But the reproductive phases and plant senescence appear to be causally related, and the net effect is the advent of plant senescence at a time when environmental features may become limiting—an effect which may be of positive value to the species.

Another effect of senescence of positive value may be its impact on natural selection and hence on evolutionary change. With the long life span of perennial plant species, there is a buffering against rapid evolutionary change. If a species of plant were to exist which did not senesce at all and which was subject to limited mortality, the original population would linger on and on, continuing to reproduce its original genome, and the evolutionary ability of this species to adapt to new environmental changes would be minimal. I assert, then, that in plants senescence is a catalyst for evolutionary adaptability. It is interesting to note in this connection that the most aggressive species of plants, those which adapt most readily to new environmental niches—the weeds—are predominantly annuals, in which over-all senescence imposes a rapid turnover of individuals in the population. If an advantageous genetic change occurs in an annual weed species, it is spread through the population at maximal rate because of the complete turnover of the breeding population each year.

The zoologists have already rejected the suggestion that nonsenescence would retard evolutionary change (1, 5), on the basis that in a nonsenescent population the older components would constitute an ever-decreasing part of the reproductive source and their contribution to the over-all progeny would thus be relatively small. In plant populations the situation is quite the reverse, for two reasons: the organisms are immobile and the reproductive potential increases with age. For example, in a stand of mature trees, the great bulk of the population is made up of very old individuals, and since they are immobile and there are only a given number of sites on which the

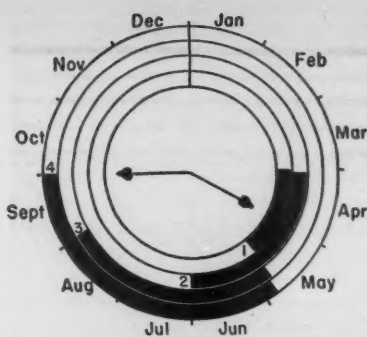


Fig. 3. A schematic clock of annual growing seasons in the Midwest, showing the periods of growth of some sample species and their termination at various points in the total growing season through the imposition of senescence. (1, 2, 3, 4) Approximate date of termination of growing season for tulip, spring wheat, soybean, and corn, respectively. Black areas, growing periods for the respective species.

trees can grow, newer individuals occupy a very small part of the space and perhaps are a very small numerical component. Even-aged forests may be constituted almost exclusively of old individuals. Furthermore, the numbers of seeds produced by individual trees may increase enormously with age, again warping the genomes of the progeny toward the genetic types of the older individuals. Therefore, it seems that the botanist can reject the concept of noninvolvement of senescence in evolutionary change and embrace the opposite view, that plant species which experience over-all senescence have a relative advantage in evolutionary adaptation in comparison with other species.

Organ senescence as well as plant senescence appears to be of positive

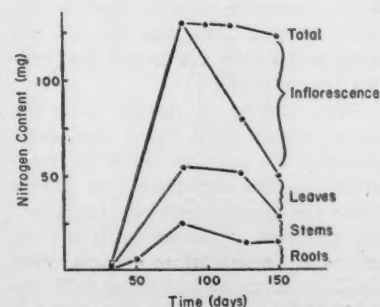


Fig. 4. Changes in the distribution of nitrogen in the oat plant during the growing period, illustrating the mobilization of nitrogenous substances into the inflorescence from the leaves, stems, and roots (6).

value to the plant. One can recognize three apparent ways in which organ senescence is beneficial. First, as individual leaves become suppressed and shaded, the onset of leaf senescence permits the recovery of the bulk of inorganic and organic nutrients which have been committed to that leaf. That nitrogenous materials are exported from aging leaves is of course well known. The data of Williams (6) illustrates this dramatically in oat plants, for with the accumulation of protein in the fruits there is an immense export of nitrogenous substances from the leaves, as shown in Fig. 4, and even a considerable export to the fruits from the stem and leaves. The retranslocation system is so effective that the oat plant does not need to assimilate any additional nitrogen during the entire last half of its life. So recovery of nutrients from senescing organs constitutes a valuable saving to the rest of the plant. A second benefit derived from organ senescence is the loss of ineffective leaves from the plant body. As leaves age and become shaded and their assimilative properties are impaired with aging, they are not supported as charity cases but, instead, are removed through organ senescence. A third benefit is obtained through the senescence of fruits. With senescence, fruits become more attractive to animals, which assist in the dissemination of seeds; furthermore, the softening of the fruits, or the dehiscence of seams in the fruits, may directly assist in the release of the seeds.

In cases where senescence is of positive value because it adapts the plant to limited periods of the growing season, there is an associated period of dormancy or rest. For example, the senescence of oats in midsummer serves to adapt the plant to a droughty midsummer season, but the adaptation is contingent upon the ability of the species to have a dormant or rest period. It seems that the ability of a species to have a dormant or rest period provides special opportunities for senescence to be of value to the organism. Perhaps a similar situation exists in some animal species; an example is the presumed senescence of butterflies after the laying of eggs (a dormant stage), which adapts some species to a limited part of the summer season.

In short, senescence in plants appears to serve numerous positive func-



Fig. 5. Deferral of senescence in soybean plants by the removal of flowers and fruits during the growing season (8).

tions, in contrast to its role in most animals. Furthermore, senescence has become highly intensified in some species and appears to be a necessary consequence of some positive physiological forces which kill the organ or organism, in contrast to the apparently nonspecific deterioration of the senescing higher animals.

Plant Senescence

What can we deduce about the physiological forces that underlie the development of plant senescence? The most conspicuous factor associated with plant senescence is reproduction. Of course, many species of plants die as they complete reproduction, and long ago Molisch (7) pointed out that the century plant (*Agave americana* L.) is a centenarian only in climates where it cannot become reproductive for 100 years. In some other climates it flowers and fruits in 10 years, and there the century plant is only a decennarian (if I may coin a word). Molisch observed that if he prevented annual plants from flowering and fruiting by cutting them back he could prevent senescence. The deferment of senescence can be illustrated with soybeans by the systematic removal of flowers, which maintains the plants in a green and vigorous condition for many weeks after the normal time of senescence (Fig. 5). Molisch interpreted the association of reproduction

and senescence as the mobilization of nutrients into the fruit from the rest of the plant, such a depletion leading to plant senescence (*Erschöpfungstod*). However, if one removes the reproductive organs at intervals from the time of first floral opening until just before fruit ripening, one finds that the signal causing plant senescence is accruing continuously during flowering and fruiting and is not simply associated with the filling of the fruits (8). It appears, then, that reproduction forces the plant into senescence, but the mobilization of nutrients into the fruit does not itself seem to account for senescence.

This point of view is further supported by the fact that in the case of dioecious species, the male plant and also the unpollinated female exhibit senescence, and in fact in the cases of both hemp and spinach, the male plants even die before the fruiting female plants.

The removal of flowers from the male spinach plant defers the senescence of the plant to about the same extent as does the removal of flowers from the female plants (8). The greatest deterrent to senescence is the removal of flowers before anthesis. Very similar effects are obtained with female plants, where the greatest deferment of senescence is achieved by removing flowers before pollination. The senescence signal coming from the tiny male parts is every bit as strong as the signal from the relatively large

developing fruits. In both cases, however, the plants are plunging into a state of senescence, and the removal of flower or fruit only briefly defers their demise.

The flowering of spinach plants involves the development of a large bolt or enlarging flower stem, and perhaps the removal of flowers is only briefly effective in deferring senescence because already the mobilization of nutrients is being accomplished through the enormously enlarging stem. If the mobilization effects of stem growth are responsible for the senescence, then the application of gibberellin to spinach plants kept in a noninductive photoperiod offers a nice chance to test the effect, for application of gibberellin results in a bolting response without any flowering. We have found that spinach plants forced into bolting in this way do not undergo senescence, and that only the bolting plants which do develop flowers experience senescence (9).

The development of plant senescence is reflected in the growth curve of each plant, and mention has already been made of the termination phase of the sigmoid growth curve as an event related to the onset of flowering and fruiting. In some species with relatively weak tendencies toward senescence the removal of flowers and fruits defers the termination of growth. This has been nicely demonstrated for the tomato (10), a weakly senescing species of the progressively senescing type.

In considering plant senescence and its possible physiological causes, we have recognized reproductive growth as a powerful signal. Molisch interpreted the lethal effects of reproduction as being a consequence of mobilization effects, and yet at present we are unable to quantitatively measure these effects and can only say that flowering and fruiting bring about an intensification of a signal for plant senescence; that this is identical with mobilization effects is not certain. Study of the nature of the signal is greatly needed.

Organ Senescence

The physiology of organ senescence and the forces which may control it are better understood. Studies by a wide variety of plant physiologists over the past 10 years have provided

a rather interesting description of the senescing leaf or fruit. As a leaf grows old, its photosynthetic apparatus appears to become markedly less effective, as indicated by lowered photosynthetic rates and depressed net assimilation rates. Its auxin supply dwindles, and it appears that the cause of this effect is an increase in the enzyme systems which destroy auxins. Pilet (11) has even suggested that the deterioration of the auxin regime with age is responsible for organ senescence. As the leaf grows older there are changes in its metabolism of carbohydrates and proteins, and, as already mentioned, there is generally a respiratory climacteric and an associated deterioration of the chlorophyll pigments in favor of the carotenoids and anthocyanins. And as these metabolic shifts take place, there is a gross export of many of the organic and inorganic nutrients from the leaf, until abscission interrupts such traffic.

Are these senescence changes brought about by activities within the aging organ? In the case of fruits, it seems that in most instances they are, for under normal physiological circumstances maturation and ripening of the fruit appear to be triggered by the termination of development of the seed structures or by metabolic activities in the fruit itself. In the case of leaves, however, there appears to be considerable control by the rest of the plant.

The impact of the whole plant on leaf senescence was implied years ago in some observations of Stahl (12). He noted that when leaves of some trees had started to yellow, a crack or incision across the leaf would locally defer the yellowing. In a very clever experiment he punched a leaf disk out of a leaf of *Philadelphus* and showed that while the remaining parts of the leaf yellowed and died, the disk which had been removed remained green. Such evidence suggests that senescence in leaves may be a correlation effect—that is, it may be a function which is controlled by physiological events occurring in remote parts of the organism.

In the progressive senescence of organs, the first organ to go is the cotyledon. Its senescence is not simply a running-out or deterioration but is controlled by the apex, as is readily demonstrated by the removal of the apex of bean seedlings at different intervals after germination. In the snap

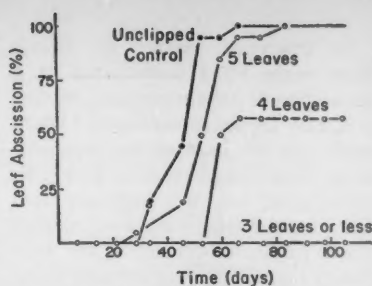


Fig. 6. The abscission of primary leaves of red kidney beans as it is modified by clipping off the plant apex after the development of 5, 4, or 3 trifoliate leaves. Removal of the apex after three leaves or less had developed prevented senescence and abscission of the primary leaves.

bean, removal of the apex defers cotyledon senescence from the usual 7 days to almost a month. In soybeans, removal of the apex entirely prevents cotyledon senescence. The same apical influence applies to leaves. For example, the primary leaves of beans normally experience senescence at about 40 days of age, but removal of the stem apex at any time before the development of four or five trifoliate leaves appears to prevent quite completely the development of leaf senescence (Fig. 6). Removal of the apex not only defers yellowing and abscission of leaves and cotyledons but permits their continued growth, in a manner roughly analogous to the deferment of plant senescence by removal of the reproductive parts.

In the case of plant senescence I spoke of an increasing signal for se-

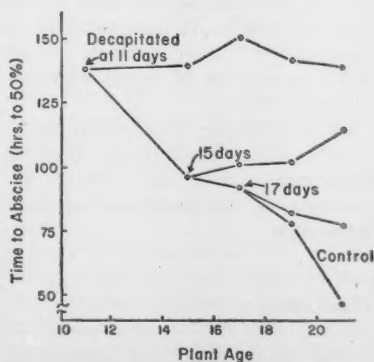


Fig. 7. Changes in the tendency of primary leaves of red kidney beans in the excised condition to abscise, as affected by age and by removal of the plant apex. Explants taken at intervals from day 11 to day 21 show an increase in speed of abscission; removal of the plant apex prevents this increase (13).

nescence. In the case of the leaf, a similar intensification of a senescence signal is provided by the apex during the functional life of the leaf. This has been illustrated nicely by Rubinstein (13) in some current studies of abscission. He excised the abscission zones of bean leaves of different ages and measured the effects of stem decapitation on the abscission processes in the excised petioles. He found (Fig. 7) that the tendency to abscise becomes increasingly greater as the leaf ages, as shown by the lessening time interval before abscission in the excised petioles. However, removal of the stem apex when the seedlings were 11 days of age prevented this physiological aging effect. Decapitation at 15 or at 17 days also deferred further increases in the tendency to abscise.

The influence of the growing point is further evidenced in the observed tendency of leaves of decapitated plants to continue to grow. For example, the cotyledons of tomato seedlings respond to decapitation of the stem by growing to as much as three times their ordinary size.

Mobilization Effects

The ability of some parts of plants to mobilize substances from other parts has been known for years, though the phenomenon has not received general attention. The abilities of flowers and fruits to mobilize carbohydrates, phosphorus, potassium, and organic nitrogen was described beautifully by Mason and Maskell (14). Curtis and Clark (15) have observed that mobilizing forces seem to be strongest in flowers and fruits, less strong in growing points, still less strong in lateral buds, weakest in roots. While the means by which such mobilizations occur remains completely obscure, there is good reason to accept the concept that such forces pull materials from one part of a plant to another, and to believe that the reproductive organs of the plants are among the most effectual mobilizing centers.

Some very telling experiments on mobilization in connection with senescence have been carried out recently by Mothes and his group in Germany. In the course of these studies he found that, while excised leaves of tobacco lose their color and senesce rapidly, leaves which are rooted escape senescence entirely (16). Extrapolating

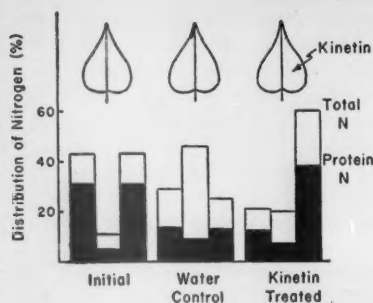


Fig. 8. Changes in distribution of total nitrogen and protein nitrogen in tobacco leaves and the modification of these changes with kinetin treatment. (Left) Initial distribution of nitrogen fractions in the left and right halves of the leaf blade and the central vein; (middle) distribution after 9 days in untreated leaves; (right) distribution after 9 days in leaves treated on one side with kinetin (30 parts per million) (25).

to the situation in the plant, he suggested that the chief mobilizing centers in the plant compete for organic nutrients which are synthesized principally in the roots, and hence an exclusive root supply to an excised leaf will avert its senescence. At the time of flowering and fruiting many plants experience a decline in root activity and then the competition by mobilizing centers may become lethal to the entire plant.

Mothes and Engelbrecht (17) have made a model to simulate the action of mobilizing centers in the plant, using kinetin as a synthetic mobilizing stimulant. Richmond and Lang (18) earlier observed that applications of kinetin to excised *Xanthium* leaves effectively retarded their senescence, measured as color deterioration or as protein degradation. Mothes' group has established that kinetin can actually produce a mobilizing effect by pulling organic nitrogenous materials into the treated area of the leaf. Thus, for example, as excised *Nicotiana* leaves aged, the right and left halves of the leaf blade lost the bulk of their protein nitrogen contents, and there appeared instead a large component of soluble nitrogen components accumulating in the region of the midrib, as shown in Fig. 8. When such a leaf was treated with kinetin on one side of the midrib, there was a mobilization of nitrogen components in the treated side, reflected in an increase in both the protein nitrogen and the total nitrogen fractions.

To determine whether the kinetin effect might be a consequence of a stimulation of protein synthesis, Mothes *et al.* (19) applied an amino acid which would not be incorporated into proteins: alpha aminoisobutyric acid. This amino acid, too, was mobilized into the kinetin-treated areas—a finding which led these workers to the conclusion that kinetin was bringing about a mobilization effect first, and that a synthesis of protein might follow the mobilization function. They suggest, then, that kinetin may be a model of the forces that cause mobilization of food materials in plants.

The suggestion that kinetin treatment may alter the effectiveness of ribonucleic acid (RNA) in causing protein synthesis is attractive. In this connection Martos (20) observed that the nucleic acids of leguminous cotyledons declined with aging, an observation which has been extended by Oota and his group in Japan. Oota and Takata (21) observed that the decline in RNA in aging cotyledons was matched by a rise in RNA in the growing points of the plants, and they proposed that the transport of RNA out of aging organs was an integral part of the development of senescence. Wohlgiehn (22) has correlated a high RNA content with the conditions which defer senescence in tobacco leaves, using Mothes' type of experimental approach.

The opportunity to examine at the level of modern biochemistry the phenomenon of mobilization actions in plants is now at hand. While there is not yet an explanation of these effects, there is a suggestive implication of an association of protein synthesis and the RNA components of organs with mobilization effects.

It is interesting to speculate as to whether such biosynthetic units as these may hold at least a partial explanation of the mechanism of plant senescence.

Conclusions

The phenomenon of senescence achieves its most dramatic expression in plants, both as over-all plant senescence and as organ senescence. I believe that this important step in the life cycle of plants is, or can be, a positive force in the ability of the plant species to adapt to limitations

of the environment, either climatic or competitive, and that senescence can be a strong factor in the evolutionary adaptability of plants.

While the mechanism controlling the more or less sudden onset of plant senescence is obscure, descriptive experiments have established that there are signals from the flowers and fruits which trigger the onset of death. A somewhat parallel situation has been described for the signals controlling the organ senescence of leaves, signals, which in this case come mainly from the stem apex. There is a growing body of evidence suggesting that mobilizing forces are involved in the senescence signals, and in the case of leaf senescence these can be mimicked, at least, through the application of kinetin (23).

It is high time that we should understand more exactly what the physiological cause of plant senescence may be. We are still unable to adequately answer the classic question posed by St. Paul to the Corinthians almost 2000 years ago (24): "Oh death, where is thy sting?"

References and Notes

1. A. Comfort, *The Biology of Senescence* (Rinehart, New York, 1956).
2. G. W. Brown and M. M. Flood, *J. Am. Statist. Assn.* **42**, 562 (1947).
3. B. L. Streblor and A. S. Mildvan, *Science* **132**, 14 (1960).
4. J. E. Varner, *Ann. Rev. Plant Physiol.* **12**, 245 (1961); F. Eberhardt, *Planta* **45**, 57 (1955); E. W. Yemm, *CIBA Colloq. on Ageing* **2**, 207 (1956).
5. P. B. Medawar, *The Uniqueness of the Individual* (Basic Books, New York, 1957).
6. R. F. Williams, *Australian J. Exptl. Biol. Med. Sci.* **16**, 65 (1938).
7. H. Molisch, *Der Lebensdauer der Pflanzen* (Fischer, Berlin, 1928).
8. A. C. Leopold, E. Niedergang-Kamien, J. Janick, *Plant Physiol.* **34**, 570 (1959).
9. J. Janick and A. C. Leopold, *Nature*, in press.
10. A. E. Murneck, *Plant Physiol.* **7**, 79 (1932).
11. P. E. Pilet, *Bull. soc. vaudoise sci. nat.* **66**, 473 (1957).
12. E. Stahl, *Zur Biologie des Chlorophylls* (1909), as cited in H. Molisch (7).
13. B. Rubinstein, thesis, Purdue University (1961).
14. T. G. Mason and E. J. Maskell, *Ann. Botany (London)* **42**, 189 (1928); T. G. Mason, E. J. Maskell, E. Phillips, *ibid.* **50**, 23 (1936).
15. O. F. Curtis and D. G. Clark, *An Introduction to Plant Physiology* (McGraw-Hill, New York, 1950).
16. K. Mothes, *Naturwissenschaften* **47**, 337 (1960).
17. K. Mothes and L. Engelbrecht, *Monatsber. Deut. Akad. Wiss. Berlin* **1**, 367 (1959).
18. A. E. Richmond and A. Lang, *Science* **125**, 650 (1957).
19. K. Mothes, L. Engelbrecht, H. R. Schutte, *Physiol. Plantarum* **14**, 72 (1961).
20. L. Martos, *Naturwissenschaften* **17**, 399 (1956).
21. Y. Oota and K. Takata, *Physiol. Plantarum* **12**, 518 (1959).
22. R. Wohlgiehn, *Flora* **150**, 117 (1961).
23. Preparation of this article was supported in part by a grant from the Rockefeller Foundation. Grateful acknowledgment is also made to Jules Janick for helpful suggestions and stimulating discussions of the subject.
24. The Bible, I Cor. 15:55.
25. K. Mothes, *Colloq. Ges. physiol. Chemie* **10**(1959), 72 (1960).

Cryogenics and Nuclear Physics

Solid-state and nuclear physics advance together through research at ultralow temperatures.

R. P. Hudson

One of the most powerful stimuli to progress in scientific research is the bringing together of two ostensibly widely differing fields of endeavor. Frequently this involves the adaptation of a specialized experimental technique to an area quite different from that in which it had been previously applied. Well-known examples are the use of microwaves in solid-state spectroscopy (with an eventual repayment of the debt by way of the maser); of nuclear magnetic resonance in structural chemistry; of ultrasonic absorption to study electron-lattice interaction in metals; of cryogenic liquids for high-energy particle detection in the bubble chamber; and of radioactive materials as "tracers" in many fields of study.

The marriage of nuclear physics and cryogenics has been a particularly fruitful one. In addition to the development of the bubble chamber already cited, notable advances in the field of radioactivity have been made possible through nuclear orientation at low temperatures, while oriented radioactive nuclei may be applied, in turn, to investigating a variety of solid-state problems. Since the first successful experiments in 1951, low-temperature nuclear orientation studies have yielded much useful information on nuclear spins, moments, and decay modes of gamma emitters. When, in late 1956, the technique was applied (under the stimulus of a bold theoretical speculation) to the study of beta decay, the consequent demonstration of the nonconservation of parity resulted in a phenom-

enal burst of activity in research on the weak interactions generally.

At present, in many laboratories throughout the world, exploratory work is in progress to produce a useful degree of nuclear polarization by combining microwave and radiofrequency engineering with cryogenics and solid-state physics. When this method ("dynamic polarization") is perfected, both low-energy and high-energy nuclear physicists will seize it with enthusiasm, while along the way the atomic physicist is discovering much of interest concerning interactions and relaxation processes.

Orientation of Nuclei at Low Temperatures

Static methods. According to the third law of thermodynamics, systems in internal equilibrium approach a state of perfect order (zero entropy) as the temperature is lowered toward absolute zero. There are certain classes of inorganic salts which are almost ideal paramagnetics—that is, their susceptibility χ follows the Curie law

$$\chi = kT^{-1}$$

even at temperatures as low as 1°K. Thus, in zero external magnetic field their electronic magnetic moments remain completely disordered, and the associated entropy will not fall toward zero (as required by the third law) until the weak internal constraints (interactions) become comparable with the thermal energy. This will be achieved between 0.001° and 0.1°K, depending upon the specific properties of the individual substances. The possibility of

forcing the electronic magnetic moments into a state of order at 1°K by means of an externally applied magnetic field, however, leads to the technique of cooling by isentropic demagnetization (removal of the field from a thermally isolated, initially magnetized specimen) into the region of very low temperatures indicated above.

Nuclear magnetic moments are in general about 1000 times smaller than their electronic counterparts. Hence, nuclear polarization demands a corresponding increase in the value of H/T , and one would need to apply, for example, 10,000 gauss at 0.001°K to produce a high degree of nuclear polarization. The technical difficulties besetting this direct or "brute force" method are evidently very great, and only small polarizations have been achieved in this way to date. Fortunately, here nature is for once helpful to the experimenter, providing a coupling between nuclear and electronic moments which may be made use of in specific instances to automatically align the nuclei if the electron spins are first aligned. The latter can be accomplished by producing a very low temperature by adiabatic demagnetization, and then utilizing either a relatively small external magnetic field (the Gorter-Rose method) or anisotropy, when it exists, in the crystalline electric field (the Bleaney method). A fourth method, developed by Pound, is to make use of the gradient of crystal field acting upon the nuclear electric quadrupole moment. The Bleaney and Pound methods give rise to alignment

$$\langle I_z \rangle_{av} = 0, \langle I_z^2 \rangle_{av} \neq 0$$

while the "brute force" and Gorter-Rose methods yield polarization

$$\langle I_z \rangle_{av} \neq 0$$

Here I_z is the component of the nuclear spin along the orientation axis.

Subsequently yet another technique was found—the production of nuclear polarization in ferromagnetic materials. Very recently, Russian scientists have shown that even nuclei of diamagnetic atoms are subjected to comparably intense polarizing forces (effective fields of the order of 10^6 gauss) when such atoms are alloyed in small concentrations in ferromagnetic host substances. It is thought that here one is encountering a polarization of the inner-core electrons by the "conduction electrons." The s -electrons need be only slightly

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affected to yield a powerful resultant force on the nucleus, and in fact, experience to date also suggests that it is this core polarization effect which gives the dominant contribution to H_{eff} at the nuclei of ferromagnetic substances.

Dynamic methods. The energy levels of a paramagnetic ion showing hyperfine structure are characterized (to take the simplest example) by the values of the electronic and nuclear angular momentum projection quantum numbers M and m ($=J_z$ and I_z). In a magnetic field of the order of 10^4 gauss, states of differing M are split apart, with separations in the microwave region of energy of approximately 1 cm^{-1} . Under conditions of thermal equilibrium, a Boltzmann distribution of ions over the various energy levels exists, maintained by "relaxation processes" which "flip" spins and exchange energy with the crystal lattice. These processes may be transitions involving a change (a) in M alone, (b) in m alone, or (c) in both M and m simultaneously.

When microwave energy is fed into this system, transitions are induced and the population distribution is disturbed. It is possible to equalize the populations of two separated levels, and the transition is then said to be "saturated." By bringing about an unequal distribution over states of positive and negative m , we automatically achieve nuclear polarization. There are two different ways of proceeding (we particularize to the case of $J = 1/2 = I$ for simplicity).

1) Select the microwave frequency to excite a transition of type *a*, reversing M only. Then if relaxation mode *c* is the dominant one, the partition over the $m = +1/2$ and $m = -1/2$ states is progressively driven away from the thermal equilibrium condition of equality, and nuclear polarization results. This is a method originally conceived by Overhauser for metals.

2) Excite a type of transition, reversing both spins and thus establishing a nuclear polarization. The latter is doubled when relaxation takes place by way of type *a* processes, where only the electron spin reverses. This method was developed by Jeffries.

Cases 1 and 2 are illustrated in Figs. 1 and 2, respectively, wherein $\Delta = g\beta H$, the electronic Zeeman energy, and δ is the hyperfine splitting.

Another case for the dynamic polarization of nuclei (proposed by Abragam) is that of an electron and a nucleus under weak dipolar coupling. The nuclear splitting is then just $g_n\beta_n H$. As in the above cases, the polarization achieved may be positive or negative, depending on which transition is selected for saturation. The enhancement factor is $\Delta/\delta = g\beta/g_n\beta_n$. This situation is found in paramagnetic crystals where the magnetic ions are surrounded by the protons of water of crystallization, and in various materials containing paramagnetic impurities. The latter are perhaps of most interest to the nuclear physicist, for by irradiat-

ing simple hydrocarbon materials to produce *F*-centers it is possible to have an assembly of electron spins and protons that are adulterated only by carbon and are entirely free of heavy elements.

Finally, one may mention a transient method developed by Feher. In this, a system such as was discussed at the beginning of this section is subjected to two successive rapid changes of the direct-current magnetic field in a process known as "adiabatic fast passage." The first change inverts the populations of a pair of electronic levels; the second has a similar effect on the populations of a pair of nuclear levels. Nuclear polarization results, and the system relaxes back to the equilibrium state.

Low Temperature Nuclear Orientation Experiments

General. A nucleus of a radioactive element resembles a radio antenna in that the probability of emission has a characteristic directional dependence. The analogy becomes more satisfactory if one considers an assembly of such nuclei 100 percent polarized, for then the characteristic anisotropic pattern is evidenced by the observed intensity, as in the radio propagation case. The pattern is rotationally symmetric around the polarization axis. For randomly oriented nuclei, as at room temperature, the emission is averaged out to spherical symmetry and an intermediate situation obtains for partially polarized nuclear ensembles. Alpha-ray and gamma-ray anisotropy may be observed with aligned or polarized nuclei; beta-ray asymmetry is produced only by polarized systems (1).

The precise details of the angular variation with respect to the system axis depend upon the spins of the initial, intermediate, and final states of the nucleus under study; upon the angular momentum carried away in the transition; and upon the properties of the crystal of which the parent atoms are constituents. For the method to be feasible it must be possible, of course, to satisfy the solid-state requirements, which are in general quite restrictive. Experiments to date have thus dealt chiefly with nuclei of elements in the iron group and in the rare-earth and transuranic series. It is probable that developments in the ferromagnetic alloying method and in the dynamic

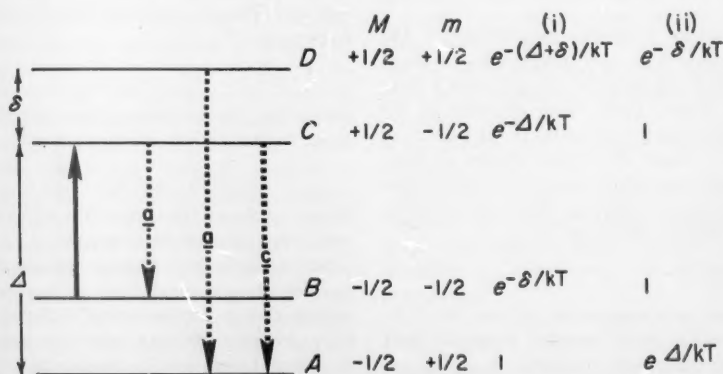


Fig. 1. (Solid arrow) "Allowed" transition selectively excited to saturation; (broken arrows) relaxation processes comprising (a) normal process, flipping only the electron spin, and (c) transition which flips electronic and nuclear spins in opposite directions ($C \rightarrow A$). (i) Thermal equilibrium populations (unnormalized); (ii) populations upon application of microwave field. The requirements are that n_C is now equal to n_B and that ratios n_D/n_A and n_C/n_A remain unaltered from the original state. Nuclear polarization, $\Sigma n_m m / \Sigma n_m \approx +\Delta/4kT$, for $\delta, \Delta \ll kT$. Since the polarization for the thermal equilibrium state (i) $\approx \delta/4kT$, an enhancement by a factor kT/δ is achieved which is of the order of 100 at liquid helium temperatures. (If relaxation process $D \rightarrow B$ should have a probability equal to that of $C \rightarrow A$, the method fails.)

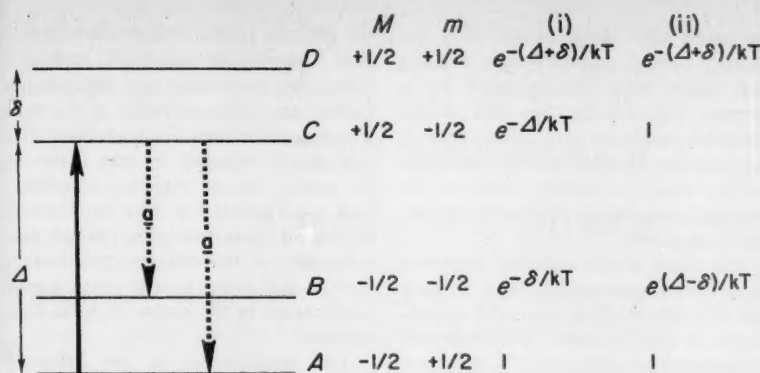


Fig. 2. (Solid arrow) "Forbidden" transition selectively excited to saturation; (broken arrows) normal relaxation process, flipping only the electron spin. (i) Thermal equilibrium populations (unnormalized); (ii) populations upon application of microwave field. The requirements are that n_B is now equal to n_A and that ratios n_C/n_B and n_D/n_A remain unaltered from the original state. Nuclear polarization $\approx -\Delta/2kT$ for $\delta, \Delta \ll kT$.

polarization field will substantially increase the number of nuclear candidates for study at low temperatures.

The orientation of a nucleus may change upon its emitting a beta particle prior to gamma decay. Thus, the "orientation parameters" determining the gamma emission will differ from those calculated for the parent nuclei under the given experimental conditions, but this can usually be taken into account quite rigorously. If, however, the lifetime of the intermediate state is long as compared with the precession period of the daughter nucleus in the polarizing field ($\tau > 10^{-8}$ sec), this is no longer true, and indeed the emission anisotropy may be considerably attenuated.

If a gamma-ray transition is "mixed" (for example, if it contains both magnetic dipole and electric quadrupole modes), the emission pattern will be affected, though the anisotropy may be either attenuated or enhanced by interference. By studying the plane polarization of the gamma radiation, too, one may obtain an independent estimate of the mixing ratio. This approach is especially useful when the mixing is such as to severely attenuate the anisotropy, an effect which might otherwise be dismissed as merely evidence that the nuclei were not being oriented.

Diminished orientation can arise from solid-state causes such as imperfect crystals, or (more fundamentally) dipolar interactions among the paramagnetic ions. When radioactive specimens are prepared by neutron bombardment of inactive crystals, it is possible to observe an increase in the radi-

ation anisotropy with successive experiments. This is due to healing from the "damage" of recoil displacement of the target ions, and hence it is possible to draw conclusions concerning the precise nature of such damage, activation energies, and so on.

Alpha-particle emission has been studied to check the theory of the effect of nuclear shape on the probability of emission and to check ideas concerning the bonding in heavy element compounds. Measurements of the spin-dependence of the slow-neutron-capture cross section tell one the spin of the compound nucleus.

The emission anisotropy may be used as a thermometric parameter, once the details have been well established in calibration experiments. The activity must always be kept low to avoid a significant heating of the specimen, hence the thermometer is a vanishingly small appendage to the system and is in intimate thermal contact, while the indication is as remote as could be desired—circumstances which approach ideality from the point of view of practical thermometry.

In sum, it is evident that not only may the numerous aspects of radioactive decay be studied by nuclear orientation methods but, conversely, the nuclear properties may be made use of in such diverse studies as crystal structure; electron-nucleus, ion-ion, and ion-lattice interactions; radiation damage; thermal equilibrium and thermometry.

Beta decay and the nonconservation of parity. The case of beta asymmetry is worthy of separate discussion in that it

involves theoretical considerations of most fundamental importance, while its observation demands very special experimental conditions. The theory of beta decay was developed by Fermi and others in the 1930's and remained unaltered basically for some twenty years. Within the framework of this theory the interaction describing the decay of a neutron into a proton plus a beta particle and a neutrino can be formulated in five distinct ways, according to the Lorentz transformation properties. There is a second set of five formulations for which the Hamiltonian function changes sign upon inversion of the coordinate system, and which were therefore rejected because of the violation of the principle of parity conservation (or space inversion invariance).

When, in 1956, Lee and Yang were facing a baffling problem in the decay of K mesons, they were tempted to question the heretofore sacrosanct principle, at least in the "weak interactions," which include K -meson and beta decays. Upon investigation, they discovered that the point had never actually been put to experimental test. Let us describe the energy of the system by the general Hamiltonian function, which contains both parity-conserving and parity-violating terms. We represent these by C and C' , scalar and pseudoscalar, respectively. The general expression for an observable as a function of the system's parameters (for example, spin, momentum, energy, and so on) will contain terms in C , $(C')^2$, and CC' . Only the last-mentioned will change sign under space-inversion (being pseudoscalar while both the others are scalar) and give rise to an asymmetry which may then be detected. Beta-decay experiments carried out prior to the Lee-Yang investigation, not involving pseudoscalar combinations of parameters, could not demonstrate the nonconservation of parity even if it existed. Lee and Yang proposed several experiments which could provide the necessary test: the distribution function for beta particles (of momentum \mathbf{p}) from polarized nuclei (of spin \mathbf{I}), for example, contains a term in $(\mathbf{I} \cdot \mathbf{p})$ which is pseudoscalar. In view of the fact that the interference term being sought might well be a small one, it was this experiment which offered the best hope of success as far as the size of an observable effect was concerned.

An important consideration here is frequently lost sight of in retrospect.

While it is true that experimentalists are not invariably deterred from "speculative" investigations, even in the face of theoretical deterrents, they are not inclined to undertake such an experiment if it is exceptionally difficult and flies in the face of a most hallowed tenet of theoretical physics, until there is at least some reason to question the latter. Thus it remained for Lee and Yang to raise the necessary doubt, and, in the event, the experiment proved to be somewhat less formidable than prior consideration suggested.

It proved possible to adapt low-temperature nuclear orientation techniques to the polarization of nuclei in thin surface layers of material, to maintain the polarized state for a usefully long period, and to perform the counting of the emitted beta particles within the inner chamber of the cryostat. The intensity of emission was found to be asymmetric with respect to the nuclear polarization vector, and the nonconservation of parity was established as a fact in nuclear beta decay. The effect was large, indeed a maximum ($C' = C$), and this circumstance made feasible a host of other experiments, in which the achievable asymmetry is much smaller than in the primary experiment. In addition to the flood of investigations into the weak interactions (β , π , and μ decays; properties of the neutrino) that followed, considerable activity was engendered in related studies (invariance principles in nuclear physics; elementary particles, and so on), which is still continuing.

Nuclear Cryogenics

Just as very low temperatures may be produced by the isentropic demagnetization of electronic paramagnetics, so, in principle, may ultralow temperatures be achieved through "nuclear cooling." Referring back to the discussion of static methods of orienting nuclei at low temperatures, however, one sees that the initial entropy reduction by isothermal magnetization can only be obtained with available magnetic-field intensities at starting temperatures of the order of 0.001°K. Thus, one is led to a two-stage process in which an electronic stage produces the starting temperature for the second, or nuclear, stage. Because the magnetizing field for the latter must not impinge upon the first stage and so reheat it, this field cannot

be made very large, except with extremely careful magnet design, and the two stages must be separated by a thermal link. Ideally, this link should have the properties of a switch, providing excellent thermal contact while the nuclear stage is cooling down to its starting temperature and complete isolation thereafter.

The many severe technical problems were finally surmounted some 5 years ago (2) with the first successful experiments in Oxford, when a nuclear-spin temperature of about 10^{-8} °K was produced. More recently the range has been extended down to 10^{-6} °K, with starting conditions of 30 kilogauss at 0.01°K. The nuclear-spin system was provided by a copper specimen which formed its own (temperature-dependent) thermal link to a compress of chromic potassium alum, the first stage. Such experiments yield information on the interaction between nuclear and electronic spins, and between the nuclear spins themselves, at extremely low temperatures. When still lower temperatures are reached, one should be able to observe the nuclear paramagnetism give way to ferromagnetic or antiferromagnetic ordering. One intriguing aspect of this type of investigation is the fantastic degree of thermal insulation demanded. For example, if the ordered state should only be manifested below, say, 10^{-7} °K, then it could be destroyed by a heat influx as small as 10 ergs per mole. But heat leaks occur by way of the crystal lattice or the electron assembly, or both, and the experiments show that the nuclear spins are very well isolated from these other systems at the very lowest temperatures.

Future Prospects

For the immediate future one may expect a continuation of conventional (as they are already regarded) experiments in which nuclear and other data are derived from alpha, beta, and gamma decays. The newer techniques for polarizing nuclei at low temperatures—the dynamic method and the incorporation of trace elements into ferromagnetics—will undoubtedly both broaden this field and open up new avenues of interest.

In the case of ferromagnetics, experiments are currently being conducted to find whether the method has general applicability to elements throughout

the periodic table; whether the effective field is positive or negative in each specific case; and what the determining factors are. Since solubility of the subject element in iron (or such other ferromagnetic materials as may prove to be useful) is an essential condition, such experiments will have implications of general interest in metal physics. Development of the dynamic polarization method will bring with it much useful information in the realm of solid-state physics.

The development of the helium-3 cryostat has made available isothermal baths at temperatures down to 0.3°K. Certain ions having very large nuclear and electronic magnetic moments can thus be used with readily available magnetic fields to yield useful degrees of nuclear polarization, which may be maintained as long as there is liquid helium in the cryostat. This will give a notable improvement in counting statistics for radioactive-decay experiments and in studies of the resonance absorption of neutrons and gamma rays.

It will be possible to study the scattering of polarized protons from polarized-proton targets when the dynamic method, applied to electron centers in hydrogen-rich materials, is perfected. The apparatus will probably incorporate helium-3 refrigeration. There are obvious problems in connection with getting the protons onto the target, and with minimizing the effect of stray field from the polarizing magnet upon the proton machine. So often in recent years, however, has the impossibility of today become the commonplace of tomorrow that such points are small cause for pessimism.

Notes

1. The terms anisotropy and asymmetry refer, respectively, to situations in which the emission is, or is not, symmetric with respect to the median plane (perpendicular to the z-axis). A beta-ray anisotropy is possible in the case of certain "forbidden" transitions.
2. This article was prepared in November 1960.

Bibliography

- A. Abragam, *Phys. Rev.* **98**, 1729 (1955).
 E. Ambler, in *Progress in Cryogenics*, K. Mendelssohn, Ed. (Heywood, London, 1960), vol. 2, p. 233.
 — and R. P. Hudson, *Repts. Progr. Phys.* **18** (1955), 251 (1956).
 D. de Klerk, *Science* **116**, 335 (1952).
 R. P. Hudson, in *Progress in Cryogenics*, K. Mendelssohn, Ed. (Heywood, London, 1961), vol. 3, p. 97.
 C. D. Jeffries, *ibid.*, vol. 3, p. 129.
 N. Kurti, *Physics Today* **11**, No. 3, 19 (1958).
 —, *Cryogenics* **1**, 1 (1960).
 T. D. Lee, *Science* **127**, 569 (1958).
 B. N. Samoilov, V. V. Skiyarevski, E. P. Stepanov, *Zhur. Eksp. i Teoret. Fiz.* **36**, 644 (1959).
 C. N. Yang, *ibid.* **127**, 565 (1958).

The International Geophysical Month

Short periods of cooperative study can consolidate the gains of the International Geophysical Year.

R. A. Helliwell and L. H. Martin

The need for concentrated studies of geophysical phenomena at selected intervals through the solar cycles has suggested the concept of International Geophysical Months, which we believe would facilitate and enhance the value of international cooperative research. International Geophysical Months are envisaged as periods of research lasting about 4 weeks, at different times and in different seasons throughout the solar cycle. The actual time and duration would be chosen by international agreement.

Experience in geophysical research has shown the exceptional advantages of establishing simultaneous and intensive studies in more than one discipline, so that study of the interrelations between the phenomena observed can be a means of evaluating alternative interpretations and of discovering new and unexpected relationships. The world-wide cooperation of the IGY proved remarkably valuable for making extensive studies of the morphology of many geophysical phenomena, both old and new. There are, however, many projects in which even more intensive observation is required to establish the characteristics of common phenomena and the detailed interrelations with associated fields. Such studies demand a concentration of effort which is not easily obtained in long-term programs and are complementary to studies more easily carried out through long-term programs of the IGY type.

Intensive observations of geophysical phenomena for periods of 3 or 4 weeks, followed by detailed analysis of the data, are usually very fruitful scientifically. Most scientific institutions can

mount and support a short-period field operation from existing resources, whereas in many cases they have neither the personnel nor the resources to carry out a long program. In the case of experiments involving cooperation between different institutions or different countries, the comparative ease with which short-term programs can be planned and carried out can lead to very successful work. Many of the facilities available in universities and other institutions cannot be efficiently deployed on relatively long-term projects. In fact, too great a stress on such projects is likely to be incompatible with the main objectives of the institutions. Intensive short-term efforts, however, can usually be made without prejudice to the long-term programs, which involve different people and equipment.

Advantages of the Concept

The advantages of the IGM concept are many, and we shall consider them under the following headings.

Quality of research. An important advantage of the IGM is that it could make better use of personnel and equipment than is now being made. New and complex experiments could be planned and carried out, and high-caliber research teams could be made available for the entire period, bringing with them advanced equipment and new ideas. Laboratory equipment can often be loaned for field operations lasting only 1 month. A further advantage is that the equipment would not have to be as reliable or as foolproof as that required for long periods of observa-

tion in the field. The opportunity it would give to evaluate new ideas which might have been formulated only a few months prior to the start of an IGM would also be an important factor.

Data reduction. The data obtained from experiments carried on during an IGM could be processed almost immediately by people closely connected with the observational phases of the program. In almost all cases it should be possible to reduce the data in time to publish the results before the succeeding IGM.

Equipment and lead time. Long lead times would not be necessary for programs of 1 month's duration where the equipment would be under the care of senior technical personnel. It must be remembered that the requirements of reliability and maintenance are not severe for short-term programs. In many cases equipment may be built by small groups on a prototype basis and operated in the field by the same group; in such instances the field researchers would have an intimate knowledge of their equipment.

Broadened participation. Important contributions to international research programs could probably be made by industrial and government enterprises which ordinarily do not participate. These groups might be glad to participate in a program lasting only 1 month and thus not seriously interfering with their normal activities. Participation in an IGM would provide a challenge to their personnel, and it would have the great advantage of bringing the problems and results of research more directly into the areas in which the results might ultimately be applied. The resulting interchange of data, ideas, and techniques would accelerate the dissemination and use of new knowledge.

A further advantage is that small research groups would be able to play a principal and active role in such short-term experiments as are envisaged in the IGM program. This should make the program especially attractive to those countries where support of scientific endeavor is restricted by limitations either of resources or of personnel.

Student participation. Perhaps the most important aspect of this proposal for International Geophysical Months

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lies in the area of education. During the summer months an IGM program could use the best available students without interfering with their educational program. Students would make preparations for 1 month, participate for 1 month, and work on data reduction for 1 month. Such an arrangement could lead to special credit in many graduate programs and might attract many of the participating students to a career in geophysical research. One of the greatest problems in research in the atmospheric sciences is that of attracting high-caliber, well-trained students. It is our experience that there is no better way to interest and attract new people than to have them participate in exciting experiments extending over a relatively short period of time.

The senior scientist. International Geophysical Months would provide a practical means of enabling senior scientists to participate in field research and would be ideally suited to the "leave" policies of most research groups. It is often possible for a faculty member or a senior scientist of a government laboratory to obtain leave for 1 month to undertake research. In an IGM program such people could accompany their assistants and work with them in performing experiments and making initial interpretations of data. In the case of educational institutions, the beneficial effect on students and faculty alike would be enormous, and in our opinion, this alone would justify the entire program.

International meetings. Since many of the top people actually working in various disciplines would be traveling to field sites, it would be possible to

organize extremely effective international gatherings at suitable times and places in connection with such field activities. Thus, an IGM in the Antarctic might be followed by a short meeting in New Zealand or Australia, at which the problems of that particular IGM could be considered. This would allow scientists to gather together while interest was high and before they had become involved in other activities.

Summary

For convenience, we summarize below some of the main advantages of the IGM concept.

1) Most organizations can mount and support intensive field operations for short periods.

2) High-quality data would be obtained, and the data could be processed more promptly than in long-term projects.

3) Laboratory equipment could in many instances be made available for field operations.

4) Top-caliber researchers would be available for field operations.

5) The participation of small research groups and of research workers from government and industry would be fostered.

6) Student participation would improve educational programs in, and attract needed talent to, the geophysical sciences.

7) Ship, satellite, and rocket observations could be scheduled for IGM's.

8) International scientific conferences scheduled to follow IGM's would attract working scientists.

It is not suggested that these short-term exercises should replace the long synoptic programs characteristic of the IGY. Rather it is proposed that they supplement and guide any such future long-term program. If adopted, they would produce many data of value for the planning and timing of the International Year of the Quiet Sun. To bring emphasis on special observations during the IQSY, International Geophysical Months might well be scheduled to coincide with the June and December solstices, to be followed by an IGM at an equinoctial period. This would provide periods for concentrated sampling—periods in somewhat the same category as the Regular World Intervals adopted during the IGY. The more elaborate experiments could be confined to the International Geophysical Months, so that only those studies for which continuous observations are essential would be scheduled for the entire period. The duration of an International Geophysical Month would be sufficient for carrying out experiments requiring moving platforms such as ships, rockets, or satellites.

It is recommended that every effort be made to schedule the first IGM during the June solstice in 1962. This initial effort could well be followed by the scheduling of IGM's during the December solstice in 1962 and the March equinox in 1963. These exercises would provide information important to the planning and scheduling of the IQSY (1).

Note

1. We acknowledge the helpful comments of W. R. Piggott and Hugh Odishaw in the preparation of this article.

Science and the News

Scientific Advisers: The Current System of Getting Advice Seems Awkward but Unavoidable

The latest in what has now become a series of congressional studies of the government's, and particularly the Defense Department's, scientific consultants is being organized by the investigations subcommittee of the House Armed Services Committee. The committee is chaired by Edward Hebert of Louisiana. It is looking into possible conflict-of-interest situations, a particularly delicate area since it is difficult nowadays, when 60 percent of the country's research is financed by the federal government, to find a scientist likely to be called on to give the government advice who does not also have connections with universities and corporations that stand to gain from contracts that may be awarded partly on the basis of his advice. When the New York Bar Association published a book-length study of the conflict-of-interest laws last year, it singled out scientists as the subject of the chapter detailing the great difficulty the government and its consultants have in living with a group of conflict-of-interest laws that grew out of scandals in military procurement during the Civil War. The general conclusion of the study was that the present conflict-of-interest laws are just not strictly enforceable except at the price of cutting the government off from its most valuable sources of advice, a price hardly anyone believes the country can afford to pay. The Bar Association recommended, and the Administration has generally endorsed, a complete rewriting of the conflict-of-interest laws which would tighten the code in some ways but which would set up a formal procedure for allowing exceptions where this is clearly in the national interest. The real problem with the present code, so far as scientists are concerned, is not that it is keeping the government from getting the advice it needs but that, because laws written so long ago are

unworkable today, they are often just ignored, with the result that if a major scandal arose it could look just so much the worse because of failure to enforce the conflict-of-interest laws.

The staff of the Herlong committee has been gathering data to be used in a public investigation after Congress reconvenes in January. Apparently they have come up with some fairly juicy items relating to stock speculation, where evidence has been developed that some consultants have used advance knowledge of where contracts would go to turn quick profits in the stock market. The staff is also trying to find evidence of the much more serious offense of consultants using their influence to direct contracts to their own universities or corporations, but this is a far more difficult charge to prove than stock speculation, which can sometimes be demonstrated quite easily simply by subpoenaing a man's stock broker. The whole business causes a good deal of uneasiness within the executive branch, for it would be a miracle if, among the thousands of possible offenders, there were not a few who had tried to make improper use of their positions, and it would be a disaster if a scandal developed of sufficient proportions to make it more difficult for the government to obtain the services of the men it wants.

Scared Off

An extreme example of the kind of thing the people who are worried about the investigation worry about is that of the lawyer who turned down a nonsalaried appointment to the Fine Arts Commission on the grounds that, under the conflict-of-interest laws as now written, it would be a violation of the law if he or any member of his law firm handled a tax case or any other case involving the government while he was serving on the Commission. It seems likely that the lawyer, in this case, was more interested in pointing up the absurdity of the conflict-of-interest laws as now written

than in protecting himself and his law partners, but the triviality of this case only emphasizes how awkward the situation could become if scientific advisors, almost all of whom have equally unavoidable and far less trivial conflict-of-interest problems, should become leery of fulfilling government requests for their advice for fear of public attack.

The other side of this problem of getting adequate scientific advice involves the position of the several dozen nonprofit corporations which have been set up in recent years primarily to serve the Defense Department. It is these corporations (the Rand Corporation is the oldest and best known) more than the conflict-of-interest problem itself that is the main subject of congressional interest. In the last couple of years they have been studied by the House Civil Service Committee, the Government Operations Committee, and the Science and Astronautics Committee, which apparently would have held public hearings this fall except for the death of its chairman, Overton Brooks, who had planned to chair a special subcommittee handling the investigation. The great reason for congressional interest in these corporations is that, although the executive branch is willing to cite any number of reasons for their existence, their primary advantage is that they offer a way to get around the civil service salary restrictions. Though it is far from being the sole source of annoyance, there is clearly a great reluctance on the part of Congress to have the government pay anyone below the rank of a cabinet member more than a Congressman earns. The problem for the government is that it has trouble getting the kind of people it wants without offering a salary and amenities that it is impossible to offer within the civil service regulations. The corporations usually serve in areas such as advanced weapon development, space, and atomic energy, where the government has had to build up its scientific staffs from scratch in a very short time, and where, therefore, the nonprofit corporation device, with its special attractions to prospective employees, seemed to be the most effective means of attracting the needed talent. The Air Force, as the newest service, relies most heavily on these corporations, and indeed would be completely lost without them.

Partly to forestall congressional

critics, the Administration initiated its own review of the nonprofit corporations last summer. Its report was supposed to be ready this week, but it became apparent weeks ago that the deadline could not be met, and the submission date has been put off until sometime early next year. The Defense Department, though, has let it be known that it is preparing a code of conduct for the nonprofit corporations intended to guard against conflict-of-interest abuses and to limit the use of the device to work which clearly could not be conducted directly by the services themselves, using regular government employees, or by industrial contractors.

But as a matter of practical politics it is hard to see how any major change is going to come out of either the congressional or the Administration's investigations. There have been some fairly serious charges made of abuses in the nonprofit corporations: the staff preparing for the Brooks investigation, for example, believed it had found evidence of one or two cases where a member of the board of a nonprofit corporation became part owner of a small profit-making corporation and then used his influence on the board of the nonprofit corporation advising the Defense Department to steer contracts to his newly formed profit-making corporation.

An entirely different sort of abuse, without moral overtones, is involved in the charge that some of the nonprofit corporations have been spending more money than is necessary, even under the usual justification for the nonprofit corporations, for high salaries and fancy buildings. Here it is difficult to define exactly when people have been unnecessarily free with the taxpayer's money, for it can be argued that if a complete organization has to be built up immediately it may be necessary to offer especially attractive pay and amenities—especially attractive even by the standard of other nonprofit corporations—to get the right kind of people as quickly as they are needed.

But there has been no indication that whatever abuses exist have been widespread enough to lead to a really major change in the handling of the nonprofit corporations. And on the level of less radical changes, nothing the government or Congress can do can completely eliminate abuses, to say nothing of mistakes in judgment, in the areas of scientific organization for the government any more than these can be

completely eliminated in any other area of human activity. Ideally, what the Administration hopes will come of the investigations is the development of a more widespread understanding of the government's problems in getting adequate scientific advice, and from this, acceptance of the need for some realistic steps toward narrowing the gap between salaries and working conditions inside and outside the government. Until this is done there will hardly be much choice but to continue to use devices like the nonprofit corporations to get the services of people the government needs. The Administration apparently intends to back a special pay scale for scientists, engineers, and perhaps some other special categories of key employees, but it is most doubtful if any reforms that get through Congress, if any get through at all, will be sufficient to really cut the need for devices to get around the civil service regulations.

Top People

Near the heart of the situation is the government's special requirement for people in rapidly developing scientific areas. Government salaries, except at the lowest levels, are now always decidedly lower than salaries for equivalent responsibilities in private employment. This makes it difficult for the government to attract and keep the most outstanding people. In areas where the need for major changes in policy does not come up too often, it is possible to get by with a good man instead of an excellent man, for even if the money saved by restricting the salaries of government employees is shortsighted economy, the loss of effectiveness is almost impossible to pinpoint. When a major series of policy changes are wanted, as when a reform-minded Administration comes to office, first-rate people can be attracted to the government to serve for 2 or 3 years to work on the new policies. One of the real accomplishments of the Kennedy Administration has been its success in drawing people to Washington. In an area like tax policy, for example, the Administration not only could get Professor Surrey to come down from Harvard Law School to head the Treasury's tax policy section, but could generate enough of a feeling of excitement to enable Surrey to recruit an elite staff of younger men, usually serving at very substantially lower salaries than they had been earning in private life, to help

work out new policies. These men are not likely to stay more than 2 or 3 years, but they can accomplish a good deal, and when they leave, the new ways of doing things can be carried on reasonably well by less-imaginative men. Things are quite different in the scientific areas, where what is urgently needed is continuously available staffs of first-rate minds.

To meet this need, the devices of the part-time consultant, such as the members of the President's Science Advisory Committee, and the government-sponsored nonprofit corporation, have grown up. Both devices have their weaknesses: the part-time consultant necessarily has outside interests, and therefore conflict-of-interest problems. The nonprofit corporation arouses the resentment of Congress, which realizes that the corporations are mainly devices to get around the government salary restrictions, and it creates difficult morale problems among the regular government scientists, who, not surprisingly, resent the double standard. But one unanswerable thing to be said for such devices is that until the public and Congress are prepared to revise their thinking about the value of government workers, the government can hardly get along without them.

Congress, or at least a sufficiently large and influential part of Congress, realizes this perfectly well, and this is why, even though the Administration is unlikely to be able to get through sufficiently far-reaching salary reforms to enable it to lessen its reliance on the nonprofit corporations, it is also unlikely that Congress will do anything to seriously impede the use of devices that have grown up to get around the restrictions Congress has been unwilling to openly abandon. For the same reason, the Congressional investigations of abuses of these devices, despite their potential, if sensationally handled, to cause a good deal of mischief, are unlikely to stir up very much of a fuss. During McCarthy's early years, there were a good many responsible Republicans who, after being out of power 20 years, were willing to encourage anyone who seemed to be undermining public confidence in the Democratic Administration. But there is no substantial group that wants to undermine public confidence in the scientific effort when it is so obviously connected with the nation's security.—H.M.

House Leadership: Changes Portend Increased Difficulties for the President's Program

The Administration found little to cheer this week in the probable leadership succession resulting from the death of House Speaker Sam Rayburn. In a sense, it was in the position of a football coach prevented from putting his best players in the backfield.

The question of intervening in the succession presents the President with a "damned-if-you-do-and-damned-if-you-don't" dilemma. He has made it clear that he intends to stay out and thereby avoid the rancor that would inevitably result from an intrusion into the House's prerogatives. There is nothing to indicate that Kennedy has moved from this intention. But there is substantial evidence that he is not happy with the likely changes, while the conservative Democrats who repeatedly helped thwart him in the past session will have a hard time concealing their delight if these changes come about. For one vital piece of the Administration's program—broad federal aid to education—the probable succession changes the future from merely gloomy to black.

McCormack Favored

The succession will be formally determined when House Democrats caucus early in January, just prior to the opening of the 1962 Congress. But on the basis of tradition, reward for loyal service, and the absence of any broadly supported alternative, Majority Leader John McCormack, of Massachusetts, appears certain to succeed Rayburn. The only suggestion of opposition has come from Albert Rains, of Alabama, who has been sending aloft trial balloons in his own behalf without any noticeable results.

Those urging the President to put his power and prestige into a succession fight have virtually conceded McCormack's elevation and are concentrating on the issue of who is to succeed him as majority leader. Well in the lead at present is Carl Albert, of Oklahoma, currently the majority whip. Challenging him is Richard Bolling, of Missouri, a Rayburn protégé and leader among House liberals. If the power to determine House leadership rested with the White House, there is little doubt that Bolling's elevation to one of the top two spots would be assured.

At issue, in the view of those who

favor the Administration's legislative program, is the question of which leaders are best equipped to steer it along the difficult political terrain of the House. In the past session, McCormack's adamant and influential stand for federal aid to private schools left wounds which are still festering. Although the school bill was undermined through a variety of political motives, McCormack has been credited with some of the more rigorously applied death blows; and as Speaker Pro Tempore during Rayburn's fatal illness, his ability at legislative infighting in behalf of the Administration was seriously put in doubt when he came out on the short end of dealings with Otto Passman, who led the fight to maintain reductions in the foreign aid appropriation.

Albert, for whom most Democrats feel only affection—which cannot be said of McCormack—has operated the whip system in a fashion that leaves doubts as to whether he is temperamentally suited for an aggressive performance as majority leader. The whip is supposedly the trumpeteer who sounds the call for the party to rally to a cause. Under Albert's reign, the call has never been a vigorous one, and in the close voting which marked the first congressional session of the Kennedy Administration, the whip system came to be regarded as suffering from leadership that was far too courteous and undemanding.

House Conservatism

The likelihood of a McCormack-Albert leadership takes on especial significance when viewed against the political arithmetic of the House. While the Senate, with its 64-36 Democratic majority, almost consistently gave the President what he requested, the House showed an inclination to steer a course that reflected the more conservative orientation of its members. In that chamber, the Democratic majority looks sizable on paper—263 to 174. Of these 263, however, some 110 are southerners, and an analysis by the *Congressional Quarterly* shows that in 33 percent of roll-call votes in the past session, a majority of the southerners lined up with the Republicans in opposition to a majority of the northerners. The "hard core" southerners number close to 50, and no leadership effort, however skillfully applied, is going to swing them to a Kennedy-Democrat line. The remainder, however, have

demonstrated sufficient political mobility to warrant emphasis on missionary efforts from the leadership. Of utmost concern for the Administration is whether the leadership can apply these efforts in competition with the skillful counterefforts of the southern conservative leadership.

The question of just what the speaker and majority leader do in the performance of their duties is an extremely difficult one. Specific duties, such as presiding over the House and scheduling the flow of legislation, are formally spelled out. But of far more importance is their function of simply talking to other members and exuding an aura of leadership in a huge and contentious body of ambitious men dedicated to a variety of goals. That Rayburn did this, and in a superlative manner, is generally agreed. That McCormack will fall far short of Rayburn's performance is extremely likely, and is of considerable concern to the Administration, which hopes to see some progress on "hard" issues, such as medical care for the aged and broad federal aid to education. Even under Rayburn's astute leadership, the conservative sentiments of the House prevailed on these issues. The succession that is most likely to result from his death does not bode well for their success.

Relations with Kennedy

The rift that developed between Kennedy and McCormack when they were both in Massachusetts politics nourished the belief, for a time, that the President would intervene to keep McCormack from rising to the post of speaker. However, Kennedy, who has no little ability to enlist individuals with a variety of political sentiments in his behalf, has made it clear that, at least as far as the speakership is concerned, he is staying away. Though his relations with McCormack have been poor for a long time, he has no desire to worsen them, regardless of how effective his efforts might be. If he thwarted McCormack's ambitions for the speakership, McCormack would remain in the majority leadership, where, with the exception of his stand on education, he has been a loyal, if not altogether effective, supporter of the Administration. In the course of his 21 years as majority leader or minority whip (the party post he filled when the Republicans controlled the 80th and 83rd congresses) McCormack has forged many bonds of loyalty and affection with in-

fluent members who would not take well to White House influence keeping him from the speakership. Were an effort made to deprive him of both leadership posts, the reaction among those who revere party loyalty would far outweigh any benefit the Administration could derive from the success of a choice of its own.

Most disturbing to the Administration's consistent supporters in the House is the likelihood that the successor to McCormack, who is close to 70, would almost certainly be Albert, who at 53 has a long career ahead of him. Except for an occasional departure on civil rights, Albert has compiled a voting record that compares well with those of most Kennedy Democrats. What is at issue is not political sympathy or personal affection but the question of who is best suited to lead the President's program through difficult and hostile territory.—D.S.G.

Science Education: Additional Federal Funds Appear Likely

The emphasis that the Soviet Union places on science education has caused widespread concern for this country to improve its own efforts. Last week it was announced that a panel of the House Education and Labor Committee would shortly open a series of meetings with scientists and educators across the country. The purpose is to obtain their views on where and how much federal money could be usefully applied to improving university science teaching. The meetings will be held privately, according to a member of the panel, to "create the best possible atmosphere for a frank discussion."

Four of the panel's five members recently returned from a trip to the Soviet Union, where they toured Soviet science teaching facilities. The members of the panel, headed by Rep. John Brademas, of Indiana, have in the past demonstrated a sympathy for expanded aid to higher education. Their present thinking is that the most expeditious course would be an expansion of existing programs under the National Defense Education Act, possibly along with the establishment of additional programs under that act.

Administration supporters on the Committee generally regard broad federal aid to education as beyond attainment in the coming session and are concentrating their efforts on exploiting

the more favorable reception accorded science training, which even foes of federal aid concede to be in the national interest.—D.S.G.

Spy in the Sky: The Air Force Would Rather Keep It Quiet

In sharp contrast to the Soviet Union, the United States has followed a remarkably wide open information policy in its space efforts. At the very least, the U.S. has always announced each launch in advance, and usually has released considerable detail. The more spectacular shots are televised. Last week, the Air Force departed sharply from this policy. For the first time in the U.S. space program, a shot was not announced in advance, and the information released afterwards was uniquely skimpy.

The unannounced launch, from the naval missile facility at Point Arguello, California, was followed by a statement announcing success and adding that "the satellite is carrying a number of classified (secret) test components."

Though no more was said, there were indications that the launching was in connection with the Air Force's satellite reconnaissance program, which gives great promise of succeeding and surpassing the U-2 as a watchful eye over the Soviet Union. Under development in the program are the Samos satellite, which is intended to produce detailed photographs of the earth's terrain, and the Midas, which is designed to detect infrared radiations from missile launches and to produce a rapid warning.

The reconnaissance potential of these satellites has stimulated some of the more vituperous Soviet propaganda of recent months, and as development of the satellites progresses, the publicity-oriented Air Force thinks, in this case, the less said the better.—D.S.G.

Educational TV: New York Sale Upheld in Last-Minute Decision

At a last-minute hearing this week, the U.S. Court of Appeals in Washington, D.C., reversed a 3-week-old decision by one of its three-judge panels, clearing the way for Educational Television for the Metropolitan Area, Inc., to purchase WNTA-TV, channel 13. The court's decision, by a 5-3 vote, came shortly before the

expiration hour of the sales contract between the educational television group and the owners of WNTA. The latter had warned that if the sale was not consummated before the deadline, they would drop plans to sell the station and would carry on commercial broadcasting.

The decision opening the way for the sale did not, however, remove all legal obstacles to ETV's New York operation. It removed the stay issued by the three-judge panel, but still left open the question of whether the Federal Communications Commission had acted properly in authorizing the sale without a public hearing.

Contesting the transaction from the outset has been Governor Robert Meyner, of New Jersey, who bases his opposition on the fact that WNTA is the state's only commercial TV station. WNTA, however, has not built a reputation for service to New Jersey, and its connection with that state is limited to the presence of its studios in Newark. Its transmitter is atop the Empire State Building, and its audience is throughout the metropolitan area.

Meyner, whose opposition to the sale has never slackened throughout the long struggle, will have an opportunity on 10 January for another effort to block the transaction. On that date, the court will hear oral arguments in the case. Should Meyner prevail, educational television will be excluded from the New York area for a long time to come.

Channel 13 is the only Very High Frequency channel up for sale in New York. The rest of the VHF band, which is the only band that most sets can receive, is occupied by stations that are not up for sale. Ample space is available on the Ultra High Frequency band, but few sets are equipped to receive UHF, and broadcasters, commercial as well as educational, are reluctant to broadcast to a nonexistent audience.

Meanwhile, the educational television group is proceeding with plans to go on the air early next year. If the sale is upheld in the forthcoming legal test, the station will join a small but thriving nationwide network of non-commercial educational TV. The resources and prestige available to a New York station will greatly enhance the position of this network and provide encouragement for its expansion.—D.S.G.

Taylor and Pfeiffer Win AAAS-Westinghouse Awards

The \$1000 AAAS-Westinghouse Science Writing Awards for 1961 will go to Rennie Taylor, of the Associated Press's San Francisco bureau, and John Pfeiffer, a free-lance writer from New Hope, Pa. William Hines, of the Washington, D.C., *Evening Star*, received his third consecutive honorable mention in the newspaper field, and, in recognition of his consistent meritorious contributions, was also granted a special citation and \$500 award. An honorable mention citation also went to A. C. B. Lovell, director of the Jodrell Bank Experimental Station and professor of radio astronomy at the University of Manchester (England), for magazine writing.

Taylor's three-part series, entitled "Sun, Space and Stars: The New Perspective Beckons Mankind," outlined the expanding knowledge man is gaining of the universe through recent penetration into space. The entry, which appeared in newspapers from coast to coast, was the last major story he filed for the Associated Press prior to his retirement. A native of Ponca, Nebr., Taylor began his newspaper career at the age of 19. He joined the AP in Denver in 1923, and began his specialty of science writing in 1937.

Pfeiffer's prize-winning article, "DNA: master substance of life," appeared in the December 1960 issue of *Natural History*. It described the properties of deoxyribonucleic acid. Born in New York in 1914, Pfeiffer has been writing about science since 1936, when he graduated from Yale and joined *Newsweek* as a science researcher. He later became science director of the Columbia Broadcasting System, and has been free-lancing for the past 10 years. His articles have appeared in the New York *Times Magazine*, *Fortune*, *Science*, and numerous other publications. His books include *The Human Brain*, *The Changing Universe: A Story of Radio Astronomy*, and *From Galaxies to Man*. His latest book, *The Thinking Machine*, will be published early in 1962.

Hines won honorable mention in the newspaper category for the third consecutive year, the latest citation being for a 15-part series, "Operation Moon," an evaluation of the government program to reach the moon in the 1960's. The series appeared in the Washington *Evening Star* from 10 to 24 September 1961.

Lovell's article, "Listening to the universe," appeared in the 15 October 1960 issue of the *Saturday Evening Post*. The entry, published as a part of the *Post's* "Adventures of the Mind" series, described how large radio telescopes are tuning in on billion-year-old signals from outer space to probe new mysteries of the universe.

The board of judges, representing the fields of journalism, science, and education, was chaired by Morris Meister, president of Bronx Community College. Other members were: Walter G. Barlow, president of Opinion Research Corporation; Norman Cousins, editor of the *Saturday Review*; Geoffrey Edsall, superintendent of the Institute of Laboratories in the Massachusetts Department of Public Health; Earl English, dean of the University of Missouri's School of Journalism; and Ralph McGill, publisher of the *Atlanta Constitution*.

The awards, made possible by a grant from the Westinghouse Educational Foundation, were established to give recognition and encouragement to outstanding science writing; to stimulate public interest in science; and to foster a deeper understanding of science by the general public. The prizes will be presented on 27 December in Denver, Colorado, during the annual meeting of the AAAS.

Announcements

An **electronic monitoring system**, capable of measuring pilot and aircraft reactions to flight in 6 seconds, has been successfully tested by the U.S. Air Force. The system, consisting of two ground-based consoles, monitors impulses from physiological and aeronautical sensors and transducers that have been placed on the pilot and in strategic parts of the plane. The impulses, radioed to a station on the ground, are amplified and sent by microwave relay to the Air Force Flight Test Center. The information is then fed into a computer and displayed on the consoles, revealing the pilot's breathing rate, reaction time, blood pressure, heart beat, body temperature, and volume of air breathed. The new system also indicates attitudes and strains on the airplane, including speed, pitch, roll, yaw, skin temperature, wing flutter and strain, and susceptibility to stall. Previous monitoring systems, which recorded

performance data of both pilot and airplane on tape, required time-consuming evaluation before flight stress could be determined. (Maj. R. M. Dudley, Office of Information, Edwards AFB, Calif.)

The National Cancer Institute has established a **virology research resources branch** to administer and develop studies on viruses as a possible cause of human cancer. The new unit, headed by Harvey I. Scudder, will use contracts to support the development of special materials needed for virus-cancer research, such as tissue-culture cell lines, virus-detection agents, special experimental animals, and normal and malignant human tissue.

An **International Society for Research in Stereoencephalotomy**—a type of brain surgery—has been established with E. A. Spiegel, professor of neurology at Temple University School of Medicine, as president. The transactions of the society will appear in *Confinia Neurologica*, published in Basel, Switzerland. (H. T. Wycis, Secretary, 3401 N. Broad St., Philadelphia 40, Pa.)

Detailed results of a 1957 survey on **scientific research and development expenditures of nonprofit organizations** have been released by the National Science Foundation. The report covers private philanthropic foundations, voluntary health agencies, independent nonprofit research institutes, certain federal-contract research centers, professional and technical societies, science museums, zoological and botanical gardens, and arboretums. (Superintendent of Documents, G.P.O., Washington 25, D.C. \$0.45)

Universities, museums, and research institutions interested in undertaking **research in Nubia, Africa**, are invited to submit detailed plans on anthropological, archeological, historical, paleontological, geological, or other research projects. (U.S. National Commission for UNESCO, Department of State, Washington 25, D.C.)

The 1960 **microfilm edition of Science** has been completed and is available in two reels. The year 1960 is priced at \$11.75; 1959, at \$10.95; and 1958, at \$9.85. The entire set from 1883 through 1957 is available at \$812. Individual out-of-print copies may also be obtained in Xerox form. (University Microfilms, Ann Arbor, Michigan)

Grants, Fellowships, and Awards

Applications are being accepted for Princeton University's fellowships and research assistantships in **plastics**, leading to the M.S. and Ph.D. in engineering. Applicants must hold a bachelor's degree in engineering or physical science. Fellowships carry stipends of \$1500 to \$2100 plus tuition and fees; half-time research assistantships provide \$2450 per academic year. (Louis F. Rahm, Plastics Laboratory, Princeton University, Princeton, N.J.)

The U.S. Atomic Energy Commission is offering special fellowships in **nuclear science and engineering** for graduates in chemistry, engineering, mathematics, or physics. Twelve-month stipends are \$1800, \$2000, and \$2200 for first-, intermediate-, and terminal-year graduates, respectively. Tuition, fees, and dependency and travel allowances are provided. Appointees will study at one of 56 selected universities having graduate programs in nuclear energy. Deadline: 5 January 1962. (NSE Fellowship Office, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.)

Students holding a professional or bachelor's degree are eligible to apply for fellowships in the **graduate institute for world affairs**, recently established at Ohio State University. The institute's program, sponsored by the Mershon Center on Education in National Security, will include seminars, conferences, and lectures in anthropology, economics, geography, history, political science, and sociology, as related to world affairs. The first conference, to be held from 30 November to 2 December, will concern the role of the military in Middle-East society and government. (Coordinator, Graduate Institute for World Affairs, 1659 N. High St., Columbus 10)

Ohio State University is offering a \$2500 award for the best book-length manuscript on **national security**, established to create an awareness of the problems of national security and to stimulate ideas which will contribute to their solution. Manuscripts need not be limited to a discussion of the military threat, but may be a treatment of economic, political, ideological, scientific, or diplomatic aspects of the problem. The winning manuscript will be

published by the university press; royalties will be paid to the author. Deadline: 2 April 1962. (Mershon Committee, Ohio State University Press, 164 W. 19th Ave., Columbus 10)

A program of annual achievement awards in **mental retardation** has been established by the Joseph P. Kennedy Jr. Memorial Foundation. Individual awards, ranging from \$5000 to \$25,000, will be presented to stimulate young scientists to enter the field, and to recognize accomplishments of senior scientists already working on mental retardation. The foundation proposes to spend up to \$250,000 annually on the awards. (Joseph P. Kennedy Jr. Foundation, 230 Park Ave., New York 17)

Scientists in the News

Robert H. Felix, director of the National Institute of Mental Health, and **Thomas B. Nolan**, director of the U.S. Geological Survey, will receive 1961 Rockefeller Public Service awards.

The following medical scientists have been appointed as U.S. representatives to study research activities in Soviet scientific centers:

William J. Zukel and **John D. Turner**, of the National Heart Institute.

Urie Bronsenbrenner, of Cornell's department of child development and family relationships.

Paul H. Densen, of the New York City health department.

Robert Dyar, of the California State Department of Public Health.

Phillip Lee, of Palo Alto Medical Clinic and Stanford University School of Medicine.

Samuel Seely, on leave from Case Institute of Technology where he is professor of electrical engineering, has been named head of the National Science Foundation's recently established engineering section. The new section replaces the foundation's engineering sciences program office.

Irvine H. Page, of the Cleveland (Ohio) Clinic, has been elected to the Brazilian Academy of Science.

Guy Suits, vice president and director of research at General Electric Company, will receive the 1962 Industrial Research Institute Medal.

Albert V. Crewe, associate professor in the University of Chicago's department of physics and the Enrico Fermi Institute for Nuclear Studies, has been appointed director of the university's Argonne National Laboratory. Crewe, director of Argonne's particle accelerator division since 1958, succeeds **Norman Hilberry**, who is retiring.

Nathaniel F. Barr, of the Sloan-Kettering Institute, and **Melvin P. Stulberg**, of Oak Ridge National Laboratory, have joined the biology branch in the U.S. Atomic Energy Commission's division of biology and medicine.

R. D. Stuart, bacteriologist and director of the Provincial Laboratory of Public Health at the University of Alberta (Canada), has won the 10th annual Kimble Methodology award. The \$1000 prize, sponsored by Kimble Glass Company, was awarded for his development of a new transport medium for bacteriological specimens.

Recent Deaths

Albert L. Andrews, 82; emeritus professor of Germanic philology at Cornell, and honorary curator of bryological collections at the university's Wiegand Herbarium; 1 Nov.

Harold F. Corson, 63; head of neuropsychiatric service at Mount Alto Veterans Hospital in Washington, D.C.; 7 Nov.

Louise Kelley, 67; retired professor of chemistry at Goucher College in Baltimore, and former technical aide with the U.S. Office of Scientific Research and Development; 12 Nov.

Harold E. Saunders, 70; technical consultant to the chief of the Navy Bureau of Ships, and former director of the Navy's David Taylor Model Basin; 11 Nov.

Winford H. Smith, 84; director of the Johns Hopkins Hospital from 1911 to 1946; 13 Nov.

Wilmer G. Stover, 80; emeritus professor of botany and plant pathology at Ohio State University; 3 Nov.

William B. Tisdale, 71; emeritus professor and former head of the department of plant pathology at the University of Florida; 26 Oct.

Luther E. Woodward, 64; senior community mental health representative for the New York State Department of Mental Hygiene since 1954; 9 Nov.

Book Reviews

Nonsystematists' Systematics

A Classification of Living Animals.

Lord Rothschild. Longmans, Green, London; Wiley, New York, 1961. vii + 106 pp. \$4.75.

It is notorious that physiologists, biochemists, biophysicists, and other scientists dealing with animals but not directly with systematics have often been vague as to the animals from which their research materials were derived. That was sometimes due to lack of interest, which is now properly considered inexcusable. The results of research are invalid if its materials are not adequately specified and placed in a taxonomic frame of reference. In other instances the fault was ignorance, sometimes excused on the grounds that the needed information was not readily accessible. Lord Rothschild's aim is to meet the latter complaint by providing an outline classification of the whole animal kingdom in one small, convenient volume.

A summary of a little over one page first lists the phyla and a few classes, with estimates of the numbers of known species. The body of the work, in 41 pages, is an outline classification of living groups, only, down to orders and sometimes, where these are in common use, suborders. For each order or suborder, one or more genera are named as examples, to the number of about 2000 in all. Synonyms still in frequent use are given parenthetically. For many genera and a few other groups an English common name is indicated. No other data are included. All names in the classification are indexed. For each common name the genus and order or suborder, as well as the page number, are given, and for each genus the order or suborder and page. The index also includes about 850 genera that are not listed in the classification, with page reference to the appropriate order or suborder. The more convenient inclu-

sion of those genera in the classification itself would not significantly have expanded the small book.

The classification depends largely, but by no means wholly, on Hyman for groups so far covered in her great treatise, *The Invertebrates*, and on the various authors of Grassé's *Traité de Zoologie*. Two classifications each are given for the Porifera (one by Burton and one by Hyman), Platyhelminthes (by Baer, hitherto unpublished, and by Dawes), and Nematoda (by Chitwood and Chitwood, and by Hyman). Rothschild has been assisted throughout by a large and distinguished body of British systematists, who are listed in the second appendix. The first appendix gives suggestions for further reading on each major group, and the works cited are listed bibliographically in the third appendix (5 pages).

The nonsystematist workers for whom the book is intended should be warned that this work will not suffice for purposes of their actual research and publication. They are told only that for the approximately 200,000 genera here necessarily unmentioned the most likely place to look is in Neave's *Nomenclator Zoologicus*. They are not told that research materials must be identified to species, at least, and that genera must be placed in families, nor are there any suggestions as to how one goes about this. Not even the *Zoological Record* is mentioned. The reading lists will often serve as a first step toward the necessary details, but often also will not. For example, the 11 citations under Reptilia include two monographs, each on a single genus (both genera unusual and one not included in the classification) but do not include Romer's *Osteology of the Reptiles*, the only work that gives a complete, modern, authoritative classification of all genera of living (as well as extinct) reptiles. As another example (one among many that could be given): the most recent

reference on Amphibia in general is 30 years old; there are no references on urodeles ("Caudata"); and the only reference on anurans ("Salientia") is to a paper on a single species. There is no mention of various textbooks, for example Storer's, that cover the whole field of this outline, that give more useful information, and that are, it would seem, equally accessible to nonspecialists.

Although Rothschild has admirably achieved his aim, it does seem a pity that the aim was quite so limited. With only a little more effort and still within the bounds of convenience and easy accessibility, this fine array of talent could have produced a work even more useful to nonsystematists. The book is nevertheless highly recommended for what it is: a handy, authoritative outline of animal classification, intermediate between a mere listing of phyla and the more extensive technicalities of textbooks, treatises, and monographs.

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Nomad and Villager

Prehistoric Man on the Great Plains.

Waldo R. Wedel. University of Oklahoma Press, Norman, 1961. xviii + 355 pp. Illus. \$5.95.

This is not a "popular" book but an annotated text and reference work in which one of the leading students of Plains archeology has effectively summarized the current knowledge of his field. The first part is a review of archeological techniques, the environmental background of the Plains area, and the story of the earliest occupants. Then the prehistoric evidences within each subarea are covered chronologically, beginning with the earliest evidences, more than 10,000 years old, and ending with the historically documented tribes of the last few centuries. A final chapter pulls the information together; this chapter is followed by an extensive bibliography and a detailed index.

In the final chapter Wedel reemphasizes his main themes. First, to understand human history on the Plains, one must take the geographical background into account. Second, there were two major native economies in the area: that of the nomadic bison-hunters of the western Plains, whose well-known 19th-

century culture represented an intensification, made possible by the acquisition of the horse, of a way of life many centuries old and that of the horticultural village dwellers of the river valleys of the eastern Plains, who dominated the Plains from about A.D. 800 to 1750.

This is an excellent job, remarkably complete and up-to-date, considering the pace at which archeological studies on the Plains are moving today. On the debit side, the usefulness of the book as a reference and text would have been enhanced by more illustrations, by subheads within the chapters, and by the presentation of trait inventories in lists rather than in discursive paragraphs. Otherwise there are few faults to find. The writing is smooth, and the interpretations are cautious but not overly so. The book will doubtless see extensive use in courses on North American archeology, and it is appropriate as a reference volume for college and public libraries alike.

E. MOTT DAVIS

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Northern Regions

Geology of the Arctic. vol. 1 and vol. 2. Gilbert O. Raasch, Ed. University of Toronto Press, Toronto, Canada, 1961. xv + 1196 pp. Illus. + maps. \$25.

The first international symposium on arctic geology, held in Calgary, Alberta, Canada, in January 1960, was a remarkable success, and the beautifully reproduced proceedings, entirely in English, are now available. The two volumes (86 papers and 16 abstracts) and a box of 34 black-and-white maps and charts present the work of 125 contributors, many of them leaders in their fields.

Section 1, Regional Geology, comprises volume 1 and consists of papers and abstracts grouped by the following areas: the Soviet arctic (4 papers, 63 pages, no references), Spitsbergen (2 papers, 76 pages, 157 references), Greenland (20 papers, 192 pages, 214 references), Canada (15 papers, 2 abstracts, 257 pages, 346 references), Alaska (1 paper, 4 abstracts, of which one is printed twice under two titles, 11 pages, 13 references), and the Arctic Ocean basin (8 papers, 3 ab-

stracts, 125 pages, 136 references). Probably for the first time, we now have available, in one volume, four excellent English-language summaries, with detailed correlation charts, of the tectonics and the Precambrian, Paleozoic, Mesozoic, and Cenozoic geology of the Soviet arctic.

The first paper on each geographic area outlines the tectonic history of the region and serves as an excellent introduction. The paper on the structural history of Spitsbergen is the longest in the volume. Papers on the geology of Greenland, with emphasis on northern and eastern Greenland, are admirably detailed and are marshalled mainly to cover the various geologic periods. Arctic Canada's stratigraphy is generalized by areas in four review papers, and the remaining 11 papers that are devoted to this area cover a variety of detailed topics, such as the gypsum tectonics and aeromagnetic studies. The only paper on Alaska deals with ostracods from the Gubik formation (Pleistocene). A fine series of papers on the Arctic Basin is introduced by Eardley's paper on theories of the origin of the basin.

One of the strongest reasons for holding a symposium to discuss polar geology is that many geological processes in polar areas either are unique or are modifications of those in the rest of the world. Section 2 (of volume 2) contains 21 papers and 8 abstracts which, with Craig and Fyle's paper in volume 1, are concerned with the fields of glaciology, climatology, glacial geology, permafrost, and geomorphology. There are ten review papers, most of which are excellent—for example, Legget's on permafrost, Thomas's on climatology, and Beschel's on lichenometry. Many of the ten original papers are good contributions, especially Smith's on ice-island morphology and Carey and Ahmad's on glacial marine sedimentation (however, this is based mostly on antarctic data).

Section 3, Logistics and Exploration (101 pages), contains several significant scientific contributions that seem out of place in a section having this title.

In summary, this expensive compilation contains a wealth of information and will provide a good reference work on arctic geology.

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Thallophyta

Lichen Handbook. A guide to the lichens of eastern North America. Mason E. Hale, Jr. Smithsonian Institution, Washington, D.C., 1961. x + 178 pp. Illus. + plates. \$4.

Although lichens are among the most numerous small plants in many areas (covering practically every tree and rock), they are the least known and least studied plants; this is probably due to the fact that a concise, accurate, popular treatment of the subject has not been available. Thus, the handbook makes a most needed contribution. Although it is intended as a semipopular introduction to lichenology, it should prove equally useful to the professional lichenologist and the amateur.

Broad but sufficiently detailed coverage is given to morphology and reproduction. Physiology is treated in somewhat more detail, and recent advances in the chemistry of lichens are covered rather thoroughly. The various lichen acids are described, and the species in which each is found are listed. The role of chemical tests in lichen identification and microchemical analyses is clearly and concisely discussed.

The most valuable part is the section devoted to collection and identification. This section contains clear, easy-to-follow (as lichens go), dichotomous keys to 30 genera and approximately 317 species of fruticose and foliose lichens known to occur in eastern North America. Also helpful is the fact that the geographical distribution, within the area, of each species is given. Owing to the difficulty of constructing a key for the crustose lichens, the approximately 100 taxa are keyed to genera only.

There are 58 figures which include many helpful drawings of lichen structure and of several species of *Cladonia*.

The 20 plates contain high quality close-up photographs of more than 90 species. There are several macrophotographs of such hard-to-illustrate key characteristics as insidia, soredia, cyphellae, pseudocyphellae, cephalodia, squamules, reticulately cracked cortex, and many others.

It is my feeling that, as a result of the publication of this long-needed and most excellent handbook, interest in the lichens will increase significantly within the next few years.

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Fresh-Water Niches

Some Aspects of Life in Fresh Water.

Edward J. Popham, Harvard University Press, Cambridge, Mass., ed. 2, 1961. 127 pp. Illus. \$2.25.

This inexpensive little book would seem to offer a balanced treatment of fresh-water ecology, judging from its table of contents: Water—A Medium for Life; Types of Aquatic Habitats; Plants of Inland Waters; Animals from the Sea; Animals from the Land; Fresh-water Communities. It is "primarily intended for undergraduate students of botany and zoology." But treatment is so uneven that the chief benefit an undergraduate might gain is some sense of excitement about various special adaptations in aquatic organisms. "The greatest changes" since the first edition (1955) retell the intriguing story of respiration in aquatic insects with captive air bubbles, which was described in 1915 by R. Ege and incorporated long ago into books such as V. B. Wigglesworth's *Principles of Insect Physiology*. Indeed, a comparison with Needham and Lloyd's *The Life of Inland Waters* (ed. 3, 1938) reveals little of the real progress made by limnologists in better than 20 years. Nearly a fifth of Popham's book is given over to an account of a Lancashire pond, 10 yards wide by about 25 yards long, of unstated depth. It is there and on the dust jacket that the concept of succession receives brief mention—but not in the index. Students may still be stimulated to examine fresh-water niches by reading this account and the "Suggestions for future study."

LORUS J. MILNE
MARGERY MILNE

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Continuity and Change

In the Ngombe Tradition. Alvin W. Wolfe. Northwestern University Press, Evanston, Ill., 1961. vi + 167 pp. Illus. \$6.50.

In anthropology, one of the more rigorous applications of the cross-cultural method of studying behavior consists in comparing different societies which lie within the same cultural stream; a great number of factors are thus kept constant, and the search for significant variables may be concen-

trated on but a few differences. It is this method that Wolfe adopts in his study (which is No. 7 in Northwestern's African Studies series) of the two sections of the Ngombe people of the Congo. As a result, what may have been simply "descriptive" ethnography becomes an exercise in refining existing theories about cultural stability and change. An interesting facet of this work is the concentration on internal changes, as opposed to acculturative changes induced by European control. Overemphasis on the latter, fruitful though it has been for cultural theory, has sometimes, and subtly, discouraged anthropologists from looking for internal mechanisms of change and has tended to support the myth of necessary stability in so-called primitive societies.

Wolfe begins by describing the two sections of the Ngombe. On the surface, the differences between them are considerable; these differences can be seen in their physical environment, in their ecology, in the economic pursuits they emphasize, in the division of labor between the sexes, in the socio-structural arrangements of village and lineage, in marriage customs, in religious activities, in the patterns of interpersonal relations. Underneath this diversity, however, Wolfe shows a large common core of cultural assumptions about the nature of the world, of man, and of supernatural forces. After demonstrating, convincingly enough, that one Ngombe group may be viewed as a derivative of a culture which the other group still largely represents, Wolfe turns to a reexamination of existing theories of cultural change. Reformulating distinctions drawn by Cassirer into anthropologically acceptable concepts, he shows that cultural elements may be subdivided according to whether they are seen as "actuality" or as "possibility" by the people concerned. "Actuality" is represented by those elements which are taken for granted as given "facts"; they are the axioms of a cultural system, which define, for the people, their unquestioned reality. Once the universe is so defined, there remain "possibilities" of manipulation, of adaptation to new conditions, of variation in behavior, of choice, and of change. It is in the realm of cultural "possibilities" that Wolfe finds most of the differences between the two Ngombe groups. The same assumptions about the universe are, quite logically, acted upon differently, given noncultural differences of setting in which action

takes place. As a result, many of the superficially striking differences in the total organization of life of the two groups are found to be largely epiphenomenal to the similarities in basic cultural assumptions. The logical theoretical correlate of this finding is that it is the cultural "possibilities" which are apt to change most easily over time.

This short summary obviously cannot examine the several fruitful theoretical byways taken by the author, nor the many further elaborations that the argument suggests to the professional anthropologist. Incidentally, the latter will wish for a future, fuller ethnographic monograph on the Ngombe to fill in details that, in the present theory-oriented work, tend to be left out. For the nonanthropologist this book can be recommended as a readable example, uncluttered by jargon, of one link in the chain of theory-building which is an integral part of the science of anthropology.

IGOR KOPYTOFF

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Chemical Synthesis

The Pfizer Handbook of Microbial Metabolites. Max W. Miller. McGraw-Hill, New York, 1961. x + 772 pp. Illus. \$15.

Substances claimed to have been isolated or identified in cultures of microorganisms, either in the medium or in the cells, are treated in this compilation. Molds, yeasts, actinomycetes, bacteria, and the like are included. Initial compounds (1313) are listed by name; the name is followed by a short note covering properties and analysis, the organism of origin, and selected references. These entries are organized into 19 chapters, one of which has 15 subdivisions. Each chapter includes a discussion of the probable metabolic origin of the class of substances treated in it. In addition, there is an addendum of 50-odd pages, whose relation to the whole is somewhat confusing, and which is not indexed.

There are a general bibliography, three appendices, and three indexes. One appendix contains references on the chemical composition of microorganisms, another provides both data

and references on microbial carotenes, and the third includes data and references on the composition of the mycobacteria. The indexes are arranged according to substance name (this one is called the subject index), empirical formula, and the organism involved.

This book obviously represents a great deal of literature searching and compilatory work. Although many organizations dealing with this area have prepared such compilations, it is helpful to have a volume available to organizations which have neither the time nor the facilities to prepare one.

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New Books

Biological and Medical Sciences

Atlas of Avian Hematology. Alfred M. Lucas and Casimir Jamroz. Superintendent of Documents, GPO, Washington, D.C., 1961. 277 pp. Illus. \$4.

Biological Structure and Function. vol. 1. T. W. Goodwin and O. Lindberg, Eds. Academic Press, New York, 1961. 375 pp. Illus. \$10.50. Proceedings of a symposium sponsored by the IUBS and the IUB.

British Flies. vol. 6, *Empididae*; pt. 2, *Hybotinae* and *Empidinae* (part). J. E. Collin. Cambridge Univ. Press, New York, 1961. pp. 223-551. Paper, \$6.

Comparative Plant Anatomy. A guide to taxonomic and evolutionary application of anatomical data in angiosperms. Sherwin Carlquist. Holt, Rinehart, and Winston, New York, 1961. 155 pp. Illus. \$5.

General Biology. Earl L. Core, Perry D. Strausbaugh, and Bernal R. Weimer. Wiley, New York, ed. 4, 1961. 564 pp. Illus. \$7.95.

Genes, Enzymes, and Inherited Diseases. H. Eldon Sutton. Holt, Rinehart, and Winston, New York, 1961. 128 pp. Illus. \$3.50.

The Giant African Snail. A problem in economic malacology. Albert R. Mead. Univ. of Chicago Press, Chicago, Ill., 1961. 274 pp. Illus. \$7.50.

Human Genetics. Principles and methods. Ching Chun Li. McGraw-Hill, New York, 1961. 227 pp. Illus. \$8.50.

An Introduction to Biochemistry. E. O'F. Walsh. Macmillan, New York, 1961. 462 pp. Illus. \$7.50.

Introduction to Protozoology. Reginald D. Manwell. St. Martin's Press, New York, 1961. 654 pp. Illus. \$12.

The Machinery of the Body. Anton J. Carlson, Victor Johnson, and H. Mead Cavert. Univ. of Chicago Press, ed. 5, 1961. 771 pp. Illus. \$6.50.

Metabolic Pathways. vol. 2. David M. Greenberg, Ed. Academic Press, New York, 1961. 827 pp. Illus. \$24.

Metabolic Pathways in Microorganisms. Vernon H. Cheldelin. Wiley, New York, 1961. 100 pp. Illus.

Methods of Tissue Culture. Raymond C. Parker. Harper, New York, ed. 3., 1961. 373 pp. \$12.

Phosphorus and Its Compounds. vol. 2, *Technology, Biological Functions, and Applications.* John R. Van Wazer, Ed. Interscience, New York, 1961. 2062 pp. Illus. \$35.

Plant Hunters in the Andes. T. Harper Goodspeed. Univ. of California Press, Berkeley, 1961. 378 pp. \$7.50.

Progress in Medicinal Chemistry. vol. 1. G. P. Ellis and G. B. West. Butterworths, Washington, D.C., 1961. 271 pp. Illus. \$11.25.

Recent Progress in Hormone Research. Proceedings of the 1960 Laurentian Hormone Conference. vol. 17. Gregory Pinus, Ed. Academic Press, New York, 1961. 608 pp. Illus. \$14.

Report of the Commission on Enzymes of the International Union of Biochemistry, 1961. Pergamon, New York, 1961. 159 pp. \$7.50.

Rogers' Inorganic Pharmaceutical Chemistry. Taito O. Soine and Charles O. Wilson. Lea and Febiger, Philadelphia, Pa., 1961. 704 pp. \$10.

Sexuality and the Genetics of Bacteria. François Jacob and Elie L. Wollman. Academic Press, New York, 1961. 389 pp. Illus. \$10.

Some Recent Developments in the Chemistry of Phosphate Esters of Biological Interest. H. Gobind Khorana. Wiley, New York, 1961. 150 pp. Illus. \$5.25.

Spores. vol. 2. H. Orin Halvorson, Ed. Burgess, Minneapolis, Minn., 1961. 305 pp. Illus. \$5.

Supersensitivity Following Lesions of the Nervous System. An aspect of the relativity of nervous integration. George W. Stavraky and Wilder Penfield. Univ. of Toronto Press, Toronto, Ont., Canada, 1961. 220 pp. Illus. \$10.

Economics and the Social Sciences

Contemporary Psychotherapies. Morris I. Stein, Ed. Free Press, Glencoe, Ill., 1961. 396 pp. \$7.50.

Human Behavior. Claire Russell and W. M. S. Russell. Little, Brown, Boston, Mass., 1961. 541 pp. Illus.

La Victoria. An early site on the Pacific Coast of Guatemala. *Papers of the Peabody Museum of Archaeology and Ethnology*, vol. 53. Michael D. Coe. Peabody Museum, Harvard Univ., Cambridge, Mass., 1961. 177 pp. Plates.

Legal and Criminal Psychology. Hans Toch, Ed. Holt, Rinehart, New York, 1961. 444 pp. \$6.

Proceedings of the Second International Conference on Operational Research. J. Banbury and J. Maitland, Eds. Wiley, New York, 1961. 827 pp. Illus. \$15. Conference organized by the International Federation of Operational Research Societies and held 5-9 September 1960.

The Psychology of Aggression. Arnold H. Buss. Wiley, New York, 1961. 317 pp. Illus. \$7.95.

Salinity Problems in the Arid Zones. Proceedings of the Teheran Symposium. UNESCO, Paris, 1961. 395 pp. Illus. \$10.50. Papers from the 1958 conference.

General

Bibliography of Fossil Vertebrates, 1949-1953. Memoir 84. C. L. Camp and H. J. Allison. Geological Soc. of America, New York, 1961. 570 pp. Fifth volume in a series listing and indexing all publications in vertebrate paleontology and paleoanthropology for the years 1928-1953.

Directory, American Council of Independent Laboratories. The Council, Washington 14, D.C., ed. 8, 1961. 125 pp. Illus.

The Nature of Genius. Andrew Gemant. Thomas, Springfield, Ill., 1961. 216 pp. \$6.50.

Prolegomena to a Theory of Language. Louis Hjelmslev. Francis J. Whitfield. Univ. of Wisconsin Press, Madison, 1961. 149 pp. \$4.

The 2nd Scientific American Book of Mathematical Puzzles and Diversions. Martin Gardner. Simon and Schuster, New York, 1961. 253 pp. Illus. \$3.95.

Mathematics, Physical Sciences, and Engineering

Advanced Organic Chemistry. Louis F. Fieser and Mary Fieser. Reinhold, New York, 1961. 1166 pp. Illus. \$14.

Advances in the Chemistry of the Coordination Compounds. Proceedings of the Sixth International Conference on Coordination Chemistry, 27 August to 1 September 1961. Stanley Kirschner, Ed. Macmillan, New York, 1961. 694 pp. Illus. \$15.

Advances in Space Science and Technology. vol. 3. Frederick I. Ordway, III, Ed. Academic Press, New York, 1961. 495 pp. Illus. \$14.

Aerospace Telemetry. Harry L. Stiltz. Ed. Prentice-Hall, Englewood Cliffs, N.J., 1961. 518 pp. Illus. Trade ed., \$15; text ed., \$11.25.

Analysis of Nonlinear Control Systems. Dunston Graham and Duane McRuer. Wiley, New York, 1961. 495 pp. Illus. \$9.75.

Argon, Helium and the Rare Gases. vol. 1, *History, Occurrence, and Properties.* The elements of the helium group. Gerhard A. Cook, Ed. Interscience, New York, 1961. 449 pp. Illus. \$17.50.

An Atlas of the Moon's Far Side. The Lunik III reconnaissance. U.S.S.R. Academy of Sciences. N. P. Barabashov, A. A. Mikhailov, and Yu. N. Lipsky, Eds. Translated from the Russian by Richard B. Rodman. Interscience, New York; Sky Publishing Corp., Cambridge, Mass., 1961. 154 pp. Illus. + plates. \$7.

A Book of Curves. E. H. Lockwood. Cambridge Univ. Press, London, 1961. 210 pp. Illus. \$4.95.

Carbon-14 Compounds. John R. Catch. Butterworths, Washington, D.C., 1961. 135 pp. Illus. \$5.50.

Chemical Processing of Reactor Fuels. John F. Flagg, Ed. Academic Press, New York, 1961. 541 pp. Illus. \$17.50.

Electronic Amplifier Circuits. Theory and design. Joseph Mayo Pettit and Malcolm Myers McWhorter. McGraw-Hill, New York, 1961. 338 pp. Illus. \$9.75.

Reports

Oviparous Hermaphroditic Fish with Internal Self-Fertilization

Abstract. Adults of *Rivulus marmoratus* (Cyprinodontidae) contained eggs when dissected or laid eggs when kept alive. They invariably oviposited solo, emitting eggs in various developmental stages. Both juvenescent and senescent fish have functional ovotestes. Progeny (F₁) were obtained via a selfed great grandparent, grandparent, and parent, the last two in isolation *ab ovo*.

From morphological and related evidence it has been inferred that functional hermaphroditism is normal and widespread among serranids, sparids, and maenids (1), and perhaps some iniomous fishes will be added to this list (2). As recorded elsewhere, hermaphroditism in fishes is a sporadic, teratological phenomenon occurring in a variety of teleosts. The reproductive activities of normally hermaphroditic fish have not been described, except for the diminutive serranid *Serranellus subligarius* (Cope) (3).

The present report concerns observations made from 1958 to 1961 on a series of hermaphrodites of *Rivulus marmoratus* (Poey), a cyprinodontid of a tribe with chiefly Neotropical, Ethiopian, and Oriental forms, as compared to the more generalized and mostly North and Central American tribe of *Fundulus* and its allies (4). *Rivulus marmoratus*, a lately recognized component of the continental North American fauna (5), inhabits zones of alternate desiccation and tidal-pluvial

flooding from Key West north at least to Vero Beach, Florida. It occurs also in Cuba and in the Bahamas and has a subspecies in the Antilles (6). Unlike many of its congeners, it prefers brackish waters but thrives in our fresh-water aquaria. In other species of *Rivulus* the caudal base ocellus differs between males and females. All specimens examined from the small extant collections of the superspecies have shown the presumptive female condition; all those dissected contained eggs, although both sexes are recorded for the subspecies (6). Our search for males led to the discovery of hermaphrodites among the presumed females.

Eight fish, seven directly from the wild and one in captivity since January 1958, have been closely observed and segregated from other fish since June 1960. All of them have oviposited. Despite indications of senescence, the oldest was producing fertile eggs after 32 months in captivity. Histological sections of its gonads disclosed actively functional ovotestes. Another, in isolation for over a year, now shows signs of aging but continues to emit eggs from which young hatch. An egg from this fish, oviposited after the fish had been in isolation 25 days, was incubated, and the hatchling was reared in isolation. After 6 months this hatchling began to lay eggs. One of its eggs, in turn, was isolated, and the hatchling from this egg began to oviposit within 4 months of eclosion. A sectioned fish comparable in size and age to the last-mentioned fish at first oviposition had ovotestes with developed eggs and with sperm ducts filled by spermatids and a few spermatozoa.

Daily observations have been made throughout the year on these and other individuals to record seasonal and diurnal periodicities in behavior, oviposition, back-calculated fertilization (ovulation?) times, and the durations of intra- and extraparental incubation. These findings and the histogenesis of the gonads cannot be described here

except for salient features. The ovotestes exhibit territorial localization of the alternative gametogenic tissues. Eggs are oviposited at stages ranging from that in which the yolk vesicles and fertilization cone are disappearing to that in which the vitelline circulation is established—that is, from fertilization to Oppenheimer stage 22 (7).

Among hermaphrodites of *Rivulus marmoratus* that shared an aquarium, no obvious reproductive pairing was observed. The cyprinodont sigmoid, sexual flexure, and antecedent postures, as well as oviposition itself, were consistently assumed by single fish unattended by others. In *Serranellus subligarius*, on the other hand, cross-fertilization between hermaphrodites seems to be the rule and self-fertilization the exception, these fish alternating within minutes between the male and the female sexual role, changing their color pattern to suit the role (3). The former species is paludal and euryhaline; the latter, marine and stenohaline.

At the present writing, what appear to be three males with nuptial color have just developed from laboratory-produced eggs. These comprise a small proportion of the individuals examined, both from the wild and from our laboratory stock. If these three prove truly gonochoristic, the respective roles of hermaphrodites and gonochorists in the reproductive economy of the species come into question, and the possibility that sex determination is ecologically conditioned is being examined experimentally. In view of internal egg retention by the hermaphrodites for as long as over 2½ days of development, coition might be expected to produce mixed self- and male-fertilized eggs. The ovotestes have the gross appearance of ovaries and could only be distinguished from ovaries, if they exist, by laborious procedures; hence, the statistical incidence of putative female gonochorists would be difficult to determine.

Although the species is basically oviparous, *Rivulus marmoratus* shows a trend toward ovoviviparity—a disposition foreshadowed by an instance of egg retention by *Oryzias* (8), with phylogenetic implications because of the occurrence of oviparity, ovoviviparity, and viviparity within the order Cyprinodontiformes. This ambivalence may extend as well to hermaphroditism versus gonochorism, but the demonstrated frequency of hermaphroditism in this species affords unique access to prob-

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should not repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to one 2-column figure (that is, a figure whose width equals two columns of text) or to one 2-column table or to two 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* 125, 16 (1957)].

lems of sexual physiology and the means of adding a highly homozygous strain of fish to the very few now available (9). To the latter end, it is planned to assess, by means of fin transplantation (10), the degree of genetic relationship among mono-parental siblings and other progeny and parents of this species (11).

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References and Notes

1. L. Bertin, in *Traité de zoologie*, P. P. Grassé, Ed. (Masson, Paris, 1958), vol. 13, pp. 1584-1652; p. 2650.
2. G. R. Mead, *Deep Sea Research* 6, 234 (1960).
3. E. Clark, *Science* 129, 215 (1959).
4. G. S. Myers, *Stanford Univ. Publs. Biol. Sci.* 6, 1 (1931).
5. R. W. Harrington, Jr., and L. R. Rivas, *Copeia* 1958, 125 (1958).
6. J. J. Hoedeman, *Studia Fauna Curaçao* 8, 112 (1958).
7. J. M. Oppenheimer, *Anat. Record* 68, 1 (1938).
8. I. Amemiya and S. Murayama, *Proc. Imp. Acad. Tokyo* 7, 176 (1931).
9. M. Gordon, in *The Physiology of Fishes*, M. E. Brown, Ed. (Academic Press, New York, 1958), vol. 2, pp. 431-501.
10. K. D. Kallman and M. Gordon, *Ann. N.Y. Acad. Sci.* 73, 599 (1958).
11. This report is contribution No. 109 of the Entomological Research Center, Florida State Board of Health. The work was supported by research grant No. RG-5415, National Institutes of Health, U.S. Public Health Service. I am indebted to L. A. Webber and E. S. Harrington for assistance in the care and observation of the fish and to Dr. J. B. Leonard, Clearwater, Fla., for histological preparations.

28 July 1961

Influence of Dead-End Pores on Relative Permeability of Porous Media

Abstract. The network model is used to show that wetting phase relative permeability of porous media is only slightly influenced by the fraction of that phase trapped in dead-end pores. On the other hand, the trapping of nonwetting phase in dead-end pores is a major influence on the shape of the nonwetting phase relative permeability curve. Laboratory experiments on porous media are suggested to test these network model predictions.

Simultaneous flow of two or more fluid phases occurs in soil, oil-bearing geological formations, and biological systems. In soils and biological systems the phases are water and air; in oil-bearing rock they are oil, water, and gas. Petroleum production technologists have made extensive studies of multiphase fluid flow in porous media and they have developed the definitions and working concepts.

For fluid systems of practical interest—water and air, or water, oil, and gas—there is usually only one fluid that wets the pore surfaces while the other (or others) do not. The wetting phase for water-air and for water-oil-gas is usually water. The wetting phase is believed to be spread over the pore surface; nonwetting phase occupies the center of the pore spaces and is surrounded by wetting phase.

When two or more fluid phases simultaneously occupy the pore space in a porous material the permeability to any phase is less than the single phase permeability. Permeability is defined as the volumetric rate of flow of a fluid of unit viscosity through a cube of unit cross section under a unit pressure gradient. The permeability of the porous material to any phase in the presence of other phases, divided by the single phase permeability, is known as the relative permeability. Relative permeability to a given phase is a function of the amount of that phase present in the pore spaces and is usually plotted as a function of "saturation," that is, the volume of a phase present divided by the total pore volume. Curves A and E of Fig. 1 are typical.

The factors that govern the shape of relative permeability curves are not yet well known. Studies of network models which point to the interconnection of pores into a network structure as the most important factor have been presented previously (1, 2). That there are other factors operating is indicated by the difference in shape of the wetting and nonwetting phase relative permeability curves.

In this paper, the previously reported network model data are reexamined to determine the amount of a given phase present in a network that is trapped in dead-end pores and therefore cannot flow. For single-phase flow, the network model has no dead-end pores and may be a good representation of real porous media, such as sandstone or sintered glass (3). When two immiscible phases are present in a porous medium, then the network model predicts that a situation may arise in which tubes (pores) filled with one phase cause some tubes containing the other phase to become dead-ends. There are no data on real porous media with which to check this prediction. Experiments on miscible displacement suggested at the conclusion of this report may give such data.

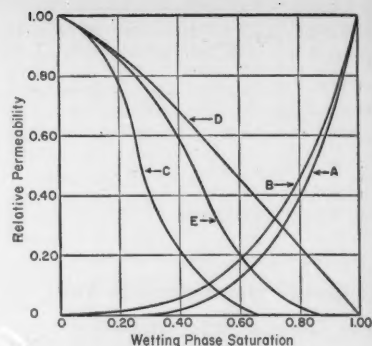


Fig. 1. Relative permeability curves for the network model (curves A, B, C, and D) and for sandstone (curve E). A and C, Wetting and nonwetting phase relative permeability, respectively, based on total volume; B and D, wetting and nonwetting phase relative permeability based on flowing volume; E, nonwetting phase relative permeability for sandstone.

The network data presented in this report, although of no quantitative significance when applied to real porous media, do indicate trends and the general appearance of relative permeability curves. These data can guide experiments designed to study the influence of pore structure on flow and diffusion in porous material.

The results of the reexamination of the data from an earlier paper (1, Figs. 5 and 6, pp. 147, 148; and Table 1, pp. 167, 168) are presented here as typical of networks which most closely represent real porous media (4).

At each saturation given in Table 1 of reference (1) the volume of each phase in dead-end tubes was recorded. This volume was subtracted from the total volume of the phase in the net-

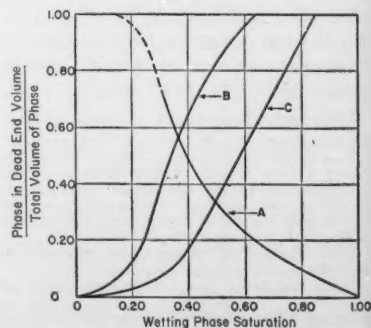


Fig. 2. Fraction of phase trapped in dead-end tubes. A, Wetting phase (from curves A and B of Fig. 1); B, nonwetting phase in network model (from curves C and D of Fig. 1); C, nonwetting phase for sandstone (from curves E and D of Fig. 1).

work to yield a saturation based on flowing volume only. Figure 1 of the present report shows the relative permeability curves obtained for increasing nonwetting phase saturation. Curves *A* and *C* are the wetting and nonwetting phase relative permeability, respectively, plotted on the basis of total volume; curves *B* and *D* are the wetting and nonwetting phase relative permeabilities plotted on the basis of flowing volume. In this graph, as in all relative permeability graphs obtained from the network model, the nonwetting phase curve based on total volume seems too far to the left when compared with curves for sandstone. This difference is believed to be a result of the small number of tubes in the model (about 400) compared to the number of pores in a sandstone sample used for relative permeability measurements. Curve *E* in Fig. 1 is typical of sandstones and is shown here for comparison.

It is apparent from Fig. 1 that the wetting phase relative permeability curve is about the same when based on total volume of wetting phase present or on flowing wetting phase. Dead-end volume is not an important influence on this curve. The factors governing the shape of the wetting phase relative permeability curve can be summarized in descending order of importance as follows. Wetting phase permeability decreases with increasing nonwetting phase saturation because: (i) large pores are removed from the network that carries wetting phase; (ii) the path of the wetting phase becomes more tortuous; and (iii) some wetting phase is trapped in dead-end pores which are not available as flow paths.

Figure 1 shows that nonwetting phase permeability is greatly influenced by dead-end volume. When plotted on the basis of saturation of flowing volume, the nonwetting phase relative permeability curve is almost a 45° line, which indicates that nonwetting permeability is almost proportional to flowing phase saturation. The data of Fig. 1 are replotted in Fig. 2 to show the fraction of a given phase that is in dead-end tubes at any total saturation of that phase.

The factors that govern the nonwetting phase relative permeability can be summarized in descending order of importance as follows. Relative nonwetting phase permeability increases as the saturation of that phase increases because: (i) more pores become avail-

able to carry nonwetting phase; the additional pores are progressively smaller as the nonwetting phase saturation increases; (ii) less nonwetting phase is in dead-end pores as its saturation increases; and (iii) the flow paths become less tortuous.

This study of the influence of dead-end pore volume suggests several experiments on real porous media to check the predictions of the network model. Handy's (5) two-tracer miscible displacement study seems to offer the best experimental procedure. In Handy's experiment, both a fast diffusing and slow diffusing tracer are in the displacing fluid. The dispersion of the slow diffusing tracer is taken to be a measure of dispersion due to mixing only; dispersion of the fast diffusing tracers is a measure of both mixing and diffusion. Dead-end pore volume will increase loss only of the fast diffusing tracer from the displacement front. The two-tracer displacement tests should be carried out with two immiscible phases present and two tracers in each phase. Dead-end volume will cause a separation of the tracer concentrations. By repeating the experiment at different saturations, it should be possible to obtain a measure of dead-end volume as a function of saturation (6).

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References and Notes

1. I. Fatt, "The network model of porous media," *Trans. Am. Inst. Mining Met. Petrol. Engrs.* **207**, 144 (1956).
2. W. Rose, *Illinois State Geol. Survey Circ. No. 237* (1957).
3. I. Fatt, *J. Phys. Chem.* **63**, 751 (1959).
4. ———, *Science* **131**, 158 (1960).
5. L. L. Handy, *Trans. Am. Inst. Mining Met. Petrol. Engrs.* **216**, 382 (1959).
6. Acknowledgement is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, for support of this research.

14 August 1961

Ancient Agriculture in the Negev

I wish to address myself in the main to the problem of the *teleilat el 'anab*, the gravel-stone heaps and mounds, which were referred to in an article in *Science* by Evenari *et al.* (1).

In two articles (2, 3) I have detailed my position on the possible function of the *teleilat*. Briefly, I maintain that the

gravel-stone mounds and heaps (called "conical heaps and ridge mounds" in my articles) were the result of excavations of pits and ditches in which mainly vines were planted, and that the "flower-pot" heaps (not illustrated or described in the article by Evenari *et al.*; see 2, pp. 24–26) were built to put a sterile area to the same use. Over the years, the action of the elements has filled up the excavations, leaving only the stone heaps in evidence.

My main point in connection with the pits and ditches is that they formed collection basins *primarily* for rain water. The undisturbed surface surrounding the pit or ditch served as a small runoff area which supplied the necessary supplementary supply of water for the vine planted in the pit or ditch. If hand watering were necessary, as might be the case in the event of a severe drought, any water applied would be concentrated near the roots of the plant. This would be the case regardless of where the vines were planted.

In reference 28 of their article (1), Evenari *et al.* make rather short shrift of my evidence (2) and make it appear that I considered that the only water the vines received came from hand irrigation from water stored in cisterns. I have written (2, p. 27): "We must not, above all, think that vines were planted *within* the mounds, but rather in pits or trenches. In other words, the conical heaps and ridge mounds came about as a result of digging holes into the ground in which vines, and in some cases, trees were planted. . . . Aside from enabling the farmer to cultivate his vine properly, each basin or trench, which could easily have been partitioned into a series of basins, would hold winter rains and irrigation water near the roots. . . . In addition to hand irrigating the vines from water stored in cisterns, it was also possible to run small channels on an oblique line from pit to pit or trench to trench, which would catch a portion of the slope runoff during the rainy season and direct it into the basins. It is for this reason, I believe, that one never finds ridge mounds following the contour of a slope but running down it; if they had been raised along the contour, runoff would have been denied to the areas below. Furthermore, because of the heavy downpours which often occur in this region, excess runoff could have been trapped at the base of a slope and channeled into a cistern where it

Table 1. Yields of barley and wheat in Bedouin agriculture in the Negev.

Description of yield	Yield (kg/dunam)	
	Barley (sown: 6 to 7 kg/dunam)	Wheat (sown: 5 to 7 kg/dunam)
Excellent	200	100
Good	70-80	50
Satisfactory	40-60	30-50
Poor	0-20	0-20

was stored for later use or directed into the terraced fields."

As for the number of heaps per hectare, Evenari *et al.* once more misread my material. I have stated (2, p. 22) that the number of "flower-pot" heaps, the only kind which would require hand irrigation exclusively, only number about 50 (*sic*) to the hectare, whereas the conical heaps, which represented the residue of excavated pits (planting holes), number about 600 to the hectare.

In order to support the above theory, I cited possible analogies, ancient and modern, from the Mediterranean and European regions; of particular significance were the citations from Apulia, southern Italy, where aerial photographs revealed ancient patterns similar to those found in the Negev. I also pointed out that when settlement workers in the Negev settlement of Ashalim planted eucalyptus trees on a hill top of their community, they dug pits into the *hammada*, placing the stone to one side of the excavation. As a result, a pattern of *teleilat* evolved not unlike the ancient.

With regard to the stone heaps in the Wadi Isderiyeh which do not run down from the slopes but are quite close to the wadi bed and run parallel to it, it is possible that they are leftovers of a relatively recent excavation by the Mandatory Government of Palestine for a telephone cable. But, I am puzzled over the fact that there are *three* rows of stone heaps, each row 2 meters or more apart (2, Fig. 5). Was more than one cable laid? Be that as it may, one thing is certain: an excavation of a ditch, whether for vines or telephone cables, results in a pattern of stone heaps very much like the kind that are seen on the slopes. (For further details regarding soil structure of the *hammadas*, adaptability of vines to stony soils, leaching out of salts, water storage, and arguments against the efficient-runoff theory of the

Hebrew University and Nelson Glueck, see 2, 3.)

Generally speaking, it is often difficult for scientists to think that the ancient farmer in a submarginal region would cultivate the worst soil when they never used all the "good" soils available. Aside from hydrographical reasons which at times makes it impractical to plant vines or trees in wadis in which heavy floods could uproot them and carry them off, we simply do not know enough about the terms under which the ancient farmer held tenure of his property. In other words, could the ancient farmer in the Negev have planted wherever he wished, or was he restricted to land which he owned or was assigned? The Byzantine papyri discovered at Nessana make it abundantly clear that every piece of property of the Nessanites was recorded at the district office at Elusa (modern Khalasa) and that taxes had to be paid—virtually guaranteed, regardless of sale or transfer—on that property. It is very likely that the ancient farmer, like most farmers over the world, attempted to put every bit of his land to productive use, even the "worst soils" by modern standards. Take an example from southern Italy: Why should the ancient farmer in Apulia have gone so far as to cut 1 cubic meter out of the living rock in order to create a container for his vines or tree? Yet he did it, and it is still being done, in spite of the fact that the land is, as stated by one investigator, impenetrable to the roots of trees and useless for orchards and vineyards.

Finally, the article of Evenari *et al.* and its subtitle give the reader the impression that until the recent experiments by the Hebrew University, agriculture had not been practiced in the Negev since the Byzantine period, some 1300 years ago. Again, I feel that this is quite misleading. Bedouins have been farming the Negev, even the very area of the experimental farms, for many years, and though lacking the energy and security of some of their predecessors, Bedouin farmers use virtually every method known to the ancients (particularly runoff farming) for supplementing a limited supply of water. Bedouin experience, in my opinion, is a far better index to ancient practices than is that of the experimental farmer.

Evenari *et al.*, without stating the rate of seeding, mention the "astonishing" yield of 125 kilograms of barley

per dunam achieved on "selected parts" of the experimental area (1, p. 995). My own data, gathered from Bedouins who have long cultivated the wadi beds of the Negev, are, I believe, the proper index for the calculation of ancient yields—not modern capabilities—in the region. I have recorded the rates of seeding and yields shown in Table 1, making due allowance for exaggerations (4).

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References and Notes

1. M. Evenari, L. Shanan, N. Tadmor, Y. Aharoni, *Science* 133, 979 (1961).
2. P. Mayerson, *Bull. Am. Schools Oriental Research* No. 153 (Feb. 1959).
3. —, *ibid.* No. 160 (Dec. 1960).
4. A full report of my study of the ancient agricultural practices of the region will be found in a recently published monograph, entitled *The Ancient Agricultural Regime of Nessana and the Central Negev* (British School of Archaeology in Jerusalem, London, 1961).

11 April 1961

Mayerson's discussion deals with two main points: (i) his explanation of *teleilat el 'anab* and (ii) the place of the Bedouin in the agricultural history of the Negev. We will reply briefly to the two points.

In presenting his variation of the century-old "grapevine" theory explaining the purpose of the gravel mounds and strips, Mayerson rejects our proposal that these mounds and strips were the result of clearing the surface soil of stone, in order to increase the rates of runoff from the hillsides with their poor soils and so produce sufficient runoff water for the farm units in the good bottom lands.

Mayerson infers that the gravel mounds and strips resulted from excavating pits and trenches on the hillsides for growing vines or trees or both. (For brevity we refer to Mayerson's system as "planting-pits" and "planting-trenches.") However, this speculation is not substantiated by any evidence to be found in the field. Why are there no remnants or even a semblance of remains to be found on the hillsides of one of these hundreds of thousands of planting-pits and planting-trenches that Mayerson presumes to have existed, while, on the other hand, the gravel mounds and strips have been preserved in excellent condition? If these features had ever existed cheek by jowl with the gravel mounds and strips, some outline or indication of their former exist-

ence must be found in the field today, since our own experience, as well as that of all recognized investigators in the Negev Desert, shows that man-made features leave their imprint on the desert surface for millennia. During our extensive field surveys we have not met with any evidence justifying the speculation that planting-pits and planting-trenches existed in conjunction with the gravel mounds and strips.

Mayerson suggests that these planting-pits and planting-trenches were used as "collection basins *primarily* for rain water" for growing vines or trees or both on the hillsides. However, Mayerson has failed to analyze the amount of water that would have been available to these vines if the planting pits worked as he suggests. The analysis is as follows. The total annual rainfall is 100 mm. The estimated effective annual rainfall (allowing for evaporation from soil surface, light showers of less than 3 mm, and runoff of 20 percent into planting-pits) is 50 mm, and this is probably a high estimate. This works out to an effective rainfall of 500 m³ per hectare. The number of vines (that is, mounds) is 600 per hectare (Mayerson's figure). This means that about 0.8 m³ of water would be available for the growth of each vine.

This 0.8 m³ is the maximum quantity of water each vine could have received in the very best of years and this quantity is absolutely insufficient to ensure the survival of mature vines, let alone produce grapes. In the Gaza area, where the annual rainfall is 400 mm, the unirrigated vines are grown on sandy soils with 400 to 500 vines to the hectare, and each vine requires 5 to 6 m³ of water (after allowing for evaporation from the soil surface) to produce 4000 kg of grapes per hectare. In the Lydda area irrigated vines are grown (1200 vines to the hectare) and each vine also requires 5 to 6 m³ of water (after allowing for evaporation and irrigation efficiencies) to produce 12,000 kg of grapes per hectare.

Mayerson could now suggest that the ancient farmers had special secret varieties of vines or trees (unknown to modern science) that could grow in soils of questionable value (Mayerson's admission) and with only these subminimum quantities of water. But this he cannot do since he "feels that a distortion arises from viewing the Nabataeans and Byzantines of the Negev as 'scientific' and efficient agronomists" (1).

We hope that these figures will once and for all close the discussion as to the possibility of collecting sufficient water on the hillsides for growing vines on the hillsides.

Now we come to the most serious contradiction resulting from Mayerson's theory. If the planting-pits and planting-trenches were used *primarily* for the collection of runoff water for the hillsides with their poor soils, then they would have used all the available runoff on the slope and prevented any runoff from reaching the cultivated bottom-land fields with their good soils and also would have deprived the cisterns of their runoff water! This is untenable. The bottom-land farm units and the cisterns existed and were undoubtedly dependent on runoff from the hillsides, a fact contradicting any suggestion that the farmers renounced the opportunity of cultivating the good bottom lands in favor of utilizing the poor, saline, stony hillsides of questionable agricultural value.

Finally, in objecting to our theory, Mayerson refers to unpublished information he received, of a series of experiments carried out by the Hebrew University (by us) and the Soil Conservation Service. These experiments, Mayerson maintains, showed that "undisturbed hammada gave much more runoff than the adjoining piece of ground that was bared of its upper cover. The exact percentages have not been published, but they range from 100%-200%" (2).

This statement is false. Mayerson must have been misled by an unreliable "grapevine" informant. We cooperated on the planning of these experiments, but unfortunately they were not executed under sufficiently controlled conditions, and hence we did not feel justified in publishing the results as being accurate enough and final. Mayerson's somewhat unconventional method of fact finding and publication now forces us to submit some of the preliminary results for whatever they are worth. These simulated rainfall experiments showed that the impermeable crust was formed sooner on the bare plots than on the stone-covered plots and this will result in increased rates of runoff from the bare plots. We are continuing with these experiments and will publish all the results as soon as they are completed.

Turning now to the place of the Bedouin in the agricultural history of

the Negev. Mayerson states that our article "and its subtitle give the reader the impression that until recent experiments by the Hebrew University, agriculture had not been practiced in the Negev since the Byzantine period some 1300 years ago," and in his opinion "Bedouin experience . . . is a far better index to ancient practices than is that of the experimental farmer." We stated in our article: "During the Nabataean-Roman-Byzantine period, desert agriculture reached its peak of development. After the Arab conquest, the ancient desert agriculture slowly disintegrated, and the Bedouins of the area at best merely utilize dilapidating old systems for patch cultivation." We stand by this statement and do not credit the Bedouins with being more than nomadic patch cultivators, whose primitive, backward agriculture cannot be used as an index for understanding the ancient settlers who established a permanent, intensive agriculture in the desert.

Palmer, who, unlike Mayerson, lived with the Bedouins and spoke a number of their dialects, can be regarded as an expert in this field. He has aptly summarized their role in the area and states: "The Arabs do occasionally practice agriculture, if sowing a little corn in a roughly ploughed field and leaving the irrigation to chance, can be so called, but it never occurs to them to take advantage of the works left them by their former owners of the soil. . . . By Arab I mean the Bedawi, the typical son of Ishmael. . . . The sympathy wasted already on the Red Man of North America warns me that I am treading on delicate ground, but I must nevertheless state my belief that the 'noble savage' is a simple and unmitigated nuisance. To the Bedawi this applies even more forcibly still, for wherever he goes he brings with him ruin, violence and neglect. To call him the 'son of the desert' is a misnomer; half of the desert owes its existence to him and many a fertile plain from which he has driven its useful and industrious inhabitants, becomes in his hands, like the 'South Country'—a parched and barren wilderness" (3).

Although this was written about a century ago, we agree fully with Palmer's observations and maintain that no investigator on the Negev has yet regarded the Bedouin as a civilization that contributed to the agricultural development of the Negev.

Mayerson submits "guestimates" of the barley crop of the Bedouin, and is not astonished that we reaped 125 kg of barley per dunam in a drought year of 40 mm rainfall. However, the Bedouins of the area were astonished, since they had a complete drought year and did not reap 1 kg per dunam. The purpose of our experimental farm is to replace these popular "guestimates" with scientific data.

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References

1. P. Mayerson, *Bull. Am. Schools Oriental Research* No. 153 (Feb. 1959).
2. ———, *ibid.* No. 160 (Dec. 1960).
3. E. H. Palmer, *The Desert of the Exodus* (Cambridge, England, 1871).

31 May 1961

Formation of the Periostracum in *Mercenaria mercenaria*

Abstract. A series of histochemical tests performed on the mantle of the northern quahog *Mercenaria mercenaria* L. suggest that the epithelium of the inner surface of the first fold and the underlying secretory cells function together in the formation of the periostracum in this mollusk. The secretory cells supply a phenolic substrate which, when oxidized, provides quinones capable of tanning the periostracum.

A row of columnar epithelial cells along the inner surface of the outer—that is, first—fold of the mantle of bivalve mollusks is regarded as being functional in the secretion of the periostracum (1–4). Our studies indicate that a similar group of epithelial cells in the bivalve, *Mercenaria mercenaria* L., also functions in the formation of the periostracum (5), although a conflicting report states otherwise (6). The periostracum of bivalve mollusks consists largely of a quinone-tanned protein, but the nature of the tanning process is obscure. Our histochemical tests on the mantle of *Mercenaria mercenaria* suggest that material formed in secretory cells underlying the inner epithelium of the first fold is a precursor of the tanning agent in this organism. A summary of the tests and procedures follows.

Quahogs were dug from an intertidal flat in Delaware Bay, off Cape Henlopen, Delaware, fixed in Bouin's solu-

tion within an hour after collection, and tested with Millon's reaction (7) and the argentaffin reaction (8, 9). Millon's reagent reacts with proteins containing large amounts of phenolic amino acids, principally tyrosine, while the argentaffin test has been used extensively to detect polyphenols involved in the tanning of proteins (4).

Paraffin sections cut transversely from the mantle edge were deparaffinized and treated with Millon's reagent at room temperature until maximal color developed (approximately 6 hours). Similar sections were treated with ammoniacal silver nitrate (Fontana's solution) (8) for 18 hours at 37°C and counterstained in 1-percent aqueous neutral red for 30 seconds.

A test for a polyphenol oxidase (10) was carried out on whole mantles from quahogs taken off Slaughter Beach, Delaware, a few miles north of Cape Henlopen. The clams were refrigerated (5°C) overnight and then removed from the shells while they were still alive. Whole mantles were treated with 10-percent neutral formalin for 1 hour at 22°C to harden the tissues. They were then incubated for 13 hours in 0.0056M 3,4-dihydroxyphenylalanine (DOPA) in 0.1M phosphate buffer at pH 7.4. The DOPA solution was changed after the first hour of incubation.

After the mantles were incubated in the DOPA solution, pieces were cut from the mantle edge (see Fig. 1), fixed for 24 hours in Bouin's solution, and imbedded in paraffin. Sections were counterstained in 1-percent aqueous neutral red solution. Control mantles were treated in the same manner except that they were incubated only in phosphate buffer.

The inner epithelium of the first fold, as seen in Table 1, although not reacting with either Millon's reagent or ammoniacal silver nitrate of the argentaffin reaction, did give a positive DOPA oxidase reaction, particularly near the opening of the periostracal groove. The underlying secretory cells did not react with DOPA, but their behavior in Millon's reagent and Fontana's solution showed that they contain a protein substance that has large amounts of phenolic groups.

The secretory cells have been demonstrated by several histochemical and histological techniques (5) and do not appear to be artifacts of fixation or staining. Ducts or extensions of these cells feed through the inner epithelium

Table 1. Summary of reactions observed in histochemical tests on *Mercenaria* mantle.

Tissue	Millon's	Argentaffin	DOPA oxidase
Inner epithelium of first fold	—	—	+
Underlying gland cells	+	+	—
Periostracum	+	+	++?
Outer epithelium of second fold	—	—	—

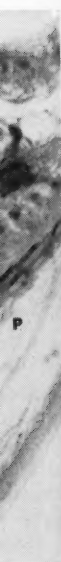
of the first fold to the periostracal groove.

The periostracum gives intense Millon and argentaffin reactions, but there were no discernible differences between the DOPA oxidase-treated periostracum and the untreated control portions. Since the periostracum is a tanned protein, it is difficult to tell whether a positive DOPA oxidase reaction is due to the enzyme or the already-tanned periostracum.

The epithelial cells themselves do not seem to contain appreciable amounts of phenolic amino acids. Apparently the only available material capable of sup-



Fig. 1. Transverse section through the mantle edge of *M. mercenaria* showing the dark-stained response of five secretory cells to Millon's reagent. In this photograph the periostracum is adpressed to the epithelium of the inner surface of the first fold by a flap of tissue which arises from the outer surface of the second fold. OE, Outer epithelium of first fold; IE, inner epithelium; SC, secretory cells; P, periostracum; SF, flap from second fold.



plying the necessary tanning agent is the product of the underlying secretory cells. A positive argentaffin reaction plus the identification of a protein substrate and a phenol oxidase provide support for the existence of a complete quinone tanning system (11). On the basis of the present research it can be postulated that the hardening of the periostracum of *M. mercenaria* may be brought about by the action of an orthoquinone produced by the oxidation of the side chains of the phenolic compound secreted by the underlying cells of the first fold. The combination of this oxidation product with either the main chains of the polypeptides, or the side chains, results in the tanning reaction. Brown (2) has suggested a self-tanning, that is, one in which the phenolic protein acts as both a substrate and a tanning agent, for the byssus of *Mytilus edulis*. Whether the product of the secretory cells undergoes self-tanning or, in an oxidized state, aids in tanning another protein, perhaps the product of the epithelial cells themselves, is not clear.

It is interesting that, except for the sulfide link found in keratinized proteins, the quinone bonding mentioned above is the only other covalent link found so far in skeletal proteins (12), and might possibly be responsible for the sclerotization of such proteins throughout the animal kingdom (11; 13).

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References and Notes

1. E. Kessel, *Z. Morphol. Ökol. Tiere* **40**, 348 (1944).
2. C. H. Brown, *Quart. J. Microscop. Sci.* **93**, 487 (1952).
3. C. M. Yonge, *Pubbl. staz. zool. Napoli* **29**, 151 (1957).
4. G. E. Beedham, *Quart. J. Microscop. Sci.* **99**, 181 (1958).
5. R. E. Hillman, unpublished.
6. G. Bevelander and P. Benzer, *Biol. Bull.* **94**, 176 (1948).
7. R. R. Bensley and I. Gersh, *Anat. Record* **57**, 217 (1933).
8. G. Gomori, *Microscopic Histochemistry* (Univ. of Chicago Press, Chicago, 1952).
9. L. Lison, *Histochimie et Cytochimie Animales* (Gauthier-Villars, Paris, 1953).
10. S. W. Becker, L. L. Praver, H. Thatcher, *Arch. klin. u. exptl. Dermatol.* **31**, 190 (1935).
11. H. Linder, *J. Morphol.* **107**, 259 (1960).
12. C. H. Brown, *Quart. J. Microscop. Sci.* **91**, 331 (1950).
13. I express my appreciation to Drs. J. H. McClendon, R. R. Ronkin, and G. F. Somers for their critical reading of the manuscript. This problem was suggested to me by Dr. C. N. Shuster, Jr., and the work was sponsored by grant G-6154 to Dr. Shuster from the National Science Foundation. This paper is contribution No. 22, University of Delaware Marine Laboratories.

19 July 1961

1 DECEMBER 1961

Luminescence Potency of the Cypridina System

Abstract. Visible light is emitted on oxidation of 0.00001 $\mu\text{g/ml}$ ($2 \times 10^{-11}M$) of *Cypridina* luciferin with 0.01 mg/ml of luciferase protein, or with 1 $\mu\text{g/ml}$ of luciferin with 0.0000001 $\mu\text{g/ml}$ ($2 \times 10^{-15}M$) of luciferase. Data on yields indicate the average content of luciferin and luciferase to be, at best, about 1 μg of each in a single living organism.

In early studies on the biochemistry of the light-emitting enzyme-substrate ("luciferase-luciferin") system of the small ostracod crustacean *Cypridina*, Harvey (1) estimated that the addition of crude luciferase to a solution containing 1 part of luciferin in from 4 to 40 billion parts of water resulted in the production of light visible to the dark-adapted eye. This estimate was based on the assumption that the raw material, consisting of whole dried organisms, contained between 1 and 10 percent luciferin by weight. Since pure, crystalline luciferin has recently been isolated from dried specimens (2) as well as from initially living organisms preserved in Dry Ice (3), and a tentative description of its structure has been made (4), more definitive estimates can now be made regarding the actual luciferin content of the organism as well as the minimal concentration, in terms of number of molecules (molecular weight 469) required for visible luminescence. The same is true with respect to luciferase; it has very recently been obtained in an essentially pure state, and its major properties have been determined (5). Moreover, when both the enzyme and substrate are pure, quantitative errors due to the influence of unknown substances, which might exert inhibitory effects on the activity of luciferase or quenching effects on the total light emission, can be eliminated.

For the experiments reported here (6), a methanolic solution of crystalline luciferin was calibrated by optical density at 435 $m\mu$ in a Beckman spectrophotometer. Pure luciferin is relatively stable in methanol, although it rapidly autoxidizes in aqueous solution exposed to air. Therefore, dilutions were made in methanol; and in accordance with Harvey's observations (1), extreme precautions (using all new glassware, and so forth) were exercised to avoid errors due to adsorption of luciferin on, and its release from, glass surfaces of pipettes and containers.

Tests for light emission were made by adding, in total darkness, 4.9 ml of a solution of 0.5 mg protein of practically pure luciferase in 0.1M sodium chloride plus 0.05M sodium phosphate buffer, pH 7.0, to 0.1 ml of a given dilution of luciferin, for simultaneous observation by three or four persons with dark-adapted eyes. A faint, momentary luminescence was clearly seen at a dilution of 1 in 10^{11} ($2 \times 10^{-11}M$ luciferin), but none at 1 in 10^{12} .

The potency of luciferase was similarly tested by adding dilutions of the enzyme in the aforementioned salt solution (glassware and blank solutions were first autoclaved) to 1 μg of luciferin in 0.1 ml of methanol. Light was observed at a final concentration of 1 part of luciferase in 10^{13} parts of solution, though not with certainty at 1 part in 10^{14} . On the basis of 50,000 as the molecular weight (5), a luciferase concentration of somewhat less than $10^{-15}M$ ($<10^{-7} \mu\text{g/ml}$) is thus sufficient to yield visible light.

Analogous experiments with respect to the actual visibility of luminescence at great dilutions of firefly luciferin and luciferase have not been reported, but the quantum efficiency of the firefly system has been measured with the lu-

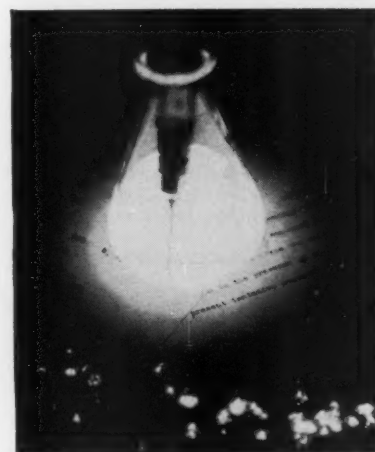


Fig. 1. Photograph taken by the light of the *Cypridina* reaction. The foreground shows individual specimens and small clumps of the organisms luminescing after removal from Dry Ice in which they were stored for about 2 months. The reaction mixture in the flask consisted of 28 ml of buffered salt solution containing 0.002 mg of pure luciferin to which was added, by the hypodermic syringe, 2 ml of salt solution containing 2 mg of practically pure luciferase. Exposure time, 1 minute at $f/2$; Tri-X Pan film.

ciferin in a concentration of $2 \times 10^{-11}M$ and found to be one quantum of light per molecule of luciferin oxidized, with an accuracy of ± 28 percent (7). The quantum efficiency of the *Cypridina* system remains to be determined. It is noteworthy, however, that a luciferin concentration of the order $10^{-11}M$, in both systems referred to above, is unusually low for a chemical test. The most sensitive qualitative tests, involving color reactions, precipitation, or fluorescence, are generally not useful at dilutions greater than 1 part in 10^{10} . Luminescence as an indicator for substances other than the specific enzyme or substrate is apparently not as sensitive; for example, the firefly system has been used to detect the cofactor adenosine triphosphate in concentrations down to about $10^{-6}M$ (8), and the "luminol reaction" to detect hydrogen peroxide in concentrations down to $10^{-7}M$ (9).

Quantitative data on the yield of pure luciferin (3, 10) and luciferase (5) from *Cypridina* indicate that the living organisms, averaging about 4 mg (wet weight) each, contain at best 1 μg of luciferin and 1 μg of luciferase, in a molecular ratio of 100 to 1. The impressively bright luminescence of these small crustaceans, amply sufficient for a self-photograph (Fig. 1), is understandable in terms of the light-emitting potency of the system, despite the seemingly minute quantities of the essential components involved.

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References and Notes

1. E. N. Harvey, *Science* **57**, 501 (1923).
2. O. Shimomura, T. Goto, Y. Hirata, *Bull. Chem. Soc. Japan* **30**, 929 (1957).
3. Y. Haneda et al., *J. Cellular Comp. Physiol.* **57**, 55 (1961).
4. Y. Hirata, O. Shimomura, S. Eguchi, *Tetrahedron Letters* No. 5, 4 (1959); O. Shimomura, *Nippon Kagaku Zasshi* **81**, 179 (1960).
5. O. Shimomura, F. H. Johnson, Y. Saiga, *J. Cellular Comp. Physiol.*, in press.
6. This research was aided in part by contract Nonr-1353(00) between the Office of Naval Research and Princeton University, by National Science Foundation grants (G-4578 and G-12857), and by the Eugene Higgins Fund allocated to Princeton University.
7. H. H. Seliger and W. D. McElroy, *Arch. Biochem. Biophys.* **88**, 136 (1960).
8. B. L. Strehler and J. R. Totter, *ibid.* **40**, 28 (1952).
9. W. V. Mayneord, W. Anderson, H. D. Evans, *D. Rosen, Radiation Research* **3**, 397 (1955).
10. We have recently obtained 60 mg of crystalline luciferin, in an approximately 50-percent yield, per kilogram (wet weight) of winter *Cypridina* preserved in Dry Ice.

14 August 1961

Glucose-6-Phosphate Dehydrogenase and Detoxification of Hydrogen Peroxide in Human Erythrocytes

Abstract. Human erythrocytes with deficient glucose-6-phosphate dehydrogenase levels are unable to maintain their levels of reduced glutathione in the presence of low-level, steady-state concentrations of hydrogen peroxide. This finding has bearing on the biochemical mechanisms of drug-induced hemolytic anemia.

Individuals with hereditary deficiencies in glucose-6-phosphate dehydrogenase (G-6-PD) are known to be sensitive to the hemolytic effects of fava bean and a wide variety of drugs, including primaquine, phenylhydrazine, and menadione (1). However, the biochemical mechanisms underlying the cellular damage induced by such compounds have not yet been clarified.

Suggestions that hydrogen peroxide might play a critical role in drug-induced hemolysis have in general been dismissed on the grounds that the high catalase activity of erythrocytes would result in rapid destruction of peroxide. Indeed, it may be readily observed that the addition of concentrated hydrogen peroxide directly to erythrocytes causes very little injury to the cells; in contrast, extensive methemoglobin formation and oxidation of reduced glutathione (GSH) may be noted when the addition of peroxide is preceded by the addition of a catalase inhibitor such as azide. However, the toxic effects of very low concentrations of hydrogen peroxide generated within cells cannot be judged from experiments such as that quoted above, namely, experiments in which much higher concentrations of peroxide are added directly to erythrocytes. For example, it has been demonstrated (2) that at low concentrations of hydrogen peroxide, the usual decomposition to water and oxygen, by catalase, yields way to a peroxidatic coupling of peroxide to various hydrogen donor molecules. In this regard, the erythrocyte enzyme glutathione peroxidase, recently reported by Mills (3), and which is capable of detoxifying hydrogen peroxide by coupling it to reduced glutathione, is of particular interest.

The primary importance of erythrocyte GSH levels in drug-induced hemolytic anemia is apparent from previous observations in erythrocytes deficient in glucose-6-phosphate dehydrogenase, of decreased average GSH levels (4), and instability of GSH in the presence of hemolytic agents such as acetylphenyl-

hydrazine (5). We have therefore re-evaluated the effect of low-level, steady-state concentrations of hydrogen peroxide on the GSH levels of normal and G-6-PD deficient erythrocytes.

In order to mimic the conditions under which hydrogen peroxide might be generated within cells, either from metabolic processes or from the autooxidation of various drugs or their metabolites, a hydrogen peroxide diffusion technique was used (6). The peroxide was added to the center well of a Warburg flask and permitted to diffuse slowly to the erythrocytes in the main compartment. A grease ring at the top of the center well prevented any cross-contamination by "creeping." The rate of diffusion of peroxide could be controlled by adjusting the amount and concentration of peroxide placed in the center well. The diffusion rate was also dependent upon the temperature, the rate of shaking, and the geometry of the flask.

Heparinized blood was obtained from a group of individuals with erythrocytes deficient in glucose-6-phosphate dehy-

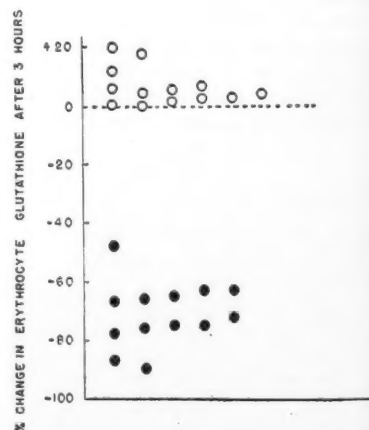


Fig. 1. Percentage change in reduced glutathione (GSH) in erythrocytes of 13 individuals with glucose-6-phosphate dehydrogenase (G-6-PD) deficiency (solid circles) and 13 individuals with normal G-6-PD activity (open circles) after 3 hours of hydrogen peroxide diffusion. Average initial GSH values were: 50 mg/100 ml (range 31 to 68 mg/100 ml) for the G-6-PD deficient erythrocytes, and 58 mg/100 ml (range 36 to 77 mg/100 ml) for the normal erythrocytes. Included in the G-6-PD deficient group were three subjects receiving isoniazid for treatment of tuberculosis; included in the normal G-6-PD group was one individual receiving isoniazid for treatment of tuberculosis, and one recovering from hemolytic anemia that was not drug-induced.

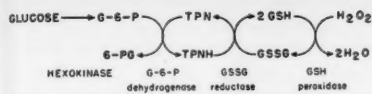


Fig. 2. The glucose-linked pathway of hydrogen peroxide detoxification.

drogenase (7) and from a group of normal volunteers. The blood, either freshly drawn or refrigerated for 12 to 24 hours, was diluted with two to three volumes of isotonic saline and centrifuged, and the supernatant fluid and buffy coat were removed by aspiration. The packed erythrocytes were then washed twice in four to six volumes of isotonic saline, and finally resuspended in three parts of isotonic saline at pH 7.4 (8), containing 250 mg of glucose per 100 ml. Three and a half milliliters of the erythrocyte suspension were placed in the main compartment of a manometric flask, and 0.25 ml of commercial 30-percent hydrogen peroxide was placed in the center well. The vessel was capped with Parafilm and incubated at 37°C in a Dubnoff metabolic incubator at a shaking speed of 90 to 100 oscillations per minute. Under these conditions, roughly 12 μ mole of hydrogen peroxide were added to the main compartment per hour, as determined by collecting the peroxide in 1N H₂SO₄ and titrating with standardized 0.01N KMnO₄.

At the end of 3 hours, the contents of the main compartment were removed and analyzed for reduced glutathione by a modification of the technique of Grunert and Phillips (9). The value at 3 hours was compared with that at zero time, and the data are expressed as percent change in reduced glutathione in 3 hours (see Fig. 1). Losses of 50 to 90 percent were observed for erythrocytes obtained from 13 individuals deficient in the dehydrogenase; no losses were observed for erythrocytes with normal levels of the enzyme. No losses in reduced glutathione were noted in control samples incubated without hydrogen peroxide.

However, losses of reduced glutathione induced by hydrogen peroxide could be obtained with normal erythrocytes also, when they were incubated in the absence of glucose. These results are similar to those reported by Beutler *et al.* (10) for the hemolytic agent acetylphenylhydrazine; they demonstrate that the protective mechanism of normal erythrocytes is linked to the metabolism of glucose.

The loss in reduced glutathione was most probably due to its oxidation, as catalyzed by the erythrocyte enzyme, glutathione peroxidase (3). Coupling of hydrogen peroxide to reduced glutathione was not catalyzed by any peroxidatic activity of catalase, since the catalase inhibitor, azide, did not block this activity, but rather augmented it. The glucose-linked protective mechanism of normal erythrocytes may best be attributed to the reduction of oxidized glutathione by the triphosphopyridine nucleotide (TPNH) specific, glutathione reductase (11); the reduced triphosphopyridine nucleotide is supplied from the activity of the hexose monophosphate shunt (see Fig. 2) (3). In G-6-PD deficient erythrocytes, the severe limitation in TPNH production from the dehydrogenation of glucose-6-phosphate (and from the subsequent dehydrogenation of 6-phosphogluconate) results in a marked inability to maintain the level of reduced glutathione in the continuous presence of low-level, steady-state concentrations of hydrogen peroxide. The major importance of the glutathione peroxidase-G-6-PD pathway for the detoxification of hydrogen peroxide in erythrocytes is illustrated by the fact that once the GSH level has fallen, other changes, such as methemoglobin formation and increased osmotic fragility, become more and more evident under the influence of diffusing peroxide (12).

These data are consistent with a mechanism of drug-induced hemolysis in G-6-PD deficient erythrocytes, in which hydrogen peroxide plays a major role. It is suggested that the oxidative damage induced by hemolytic agents is caused in part by the intermediate generation of hydrogen peroxide in low concentration from the autooxidation of the active drugs or their metabolites (13).

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References and Notes

1. E. Beutler, "Drug-induced hemolytic anemia," in *The Metabolic Basis of Inherited Disease*, J. B. Stanbury, J. B. Wyngaarden, D. S. Fredrickson, Eds. (McGraw-Hill, New York, 1960), p. 1031.
2. D. Keilin and E. F. Hartree, *Biochem. J.* **60**, 310 (1955).
3. G. C. Mills, *J. Biol. Chem.* **229**, 189 (1957); **234**, 502 (1959); *Arch. Biochem. Biophys.* **86**, 1 (1960).
4. E. Beutler *et al.*, *J. Lab. Clin. Med.* **45**, 286 (1955).

5. E. Beutler, *ibid.* **49**, 84, (1957).
6. The hydrogen peroxide diffusion technique was suggested by Dr. Irwin Fridovich, Duke University, School of Medicine. A similar technique has been reported previously [D. Keilin and E. F. Hartree, *Biochem. J.* **39**, 293 (1945)].
7. We are indebted to Dr. Ernst Jaffe of Albert Einstein College of Medicine, New York, for supplying four of these blood specimens, and to Dr. Paul Marks of Columbia University College of Physicians and Surgeons for supplying two of these specimens. The remaining G-6-PD deficient specimens were obtained by enzyme screening of a series of blood samples obtained from a randomly selected group of Negro male subjects from the Columbia-Presbyterian Medical Center; the cooperation of Pat Leitner of the out-patient department of Vanderbilt clinic is gratefully acknowledged. All of the G-6-PD deficient specimens contained less than 10 percent of the normal G-6-PD activity as measured by the technique of A. Kornberg and B. L. Horecker [in *Methods in Enzymology*, S. P. Colowick and N. O. Kaplan, Eds. (Academic Press, New York, 1955)].
8. J. V. Dacie, *The Hemolytic Anemias, Congenital and Acquired* (Churchill, London, 1954), p. 476.
9. R. A. Grunert and P. H. Phillips, *Arch. Biochem. Biophys.* **30**, 217 (1951).
10. E. Beutler, M. Robson, E. Buttenweiser, *J. Clin. Invest.* **36**, 617 (1957).
11. T. W. Rall and A. L. Lehninger, *J. Biol. Chem.* **194**, 119 (1952).
12. A more extensive report on these findings is in preparation. Preliminary reports were presented before the 45th annual meeting of the Federation of American Societies for Experimental Biology, Atlantic City, N.J., 10-14 Apr. 1961 [*Federation Proc.* **20**, 63, n.c. (1960)].
13. We acknowledge the assistance of Cynthia Chan, Morgana Martinez, and Ruth Rivlin during this investigation. This investigation was supported by U.S. Public Health Service grants H-1045 and CY 2332.

7 July 1961

Reactivity Cycle of Somatosensory Cortex in Humans with and without Psychiatric Disorder

Abstract. With a photographic averager to extract evoked cortical responses, reactivity cycles of primary potentials were determined over 200 milliseconds in 105 subjects. The typical cycle was biphasic, with peaks before 20 and after 100 msec. Subjects who were not psychiatric patients showed full recovery of responsiveness during the initial peak phase, whereas most of the psychiatric patients did not.

The purpose of this report is to describe the reactivity cycle of the somatosensory cortex in man and to present evidence that quantitative alterations in this cycle occur in psychiatric illness.

The cortical reactivity cycle is determined by applying paired "conditioning" and "test" stimuli, separated by varying intervals, to evoke cortical potentials. The relative amplitude of the two potentials (ratio of the second to the first) gives an indication of changes in cortical responsiveness with time subsequent to the first stimulus.

This procedure is similar to the classical one for determining the excitability cycle of nerve in that it uses paired stimuli; it also differs, in that response magnitude, rather than threshold, is the indicator.

There have been almost no studies of human cortical reactivity cycles because of the difficulty in detecting evoked potentials with scalp electrodes. These potentials are very small at the scalp and are obscured by the much larger "spontaneous" brain rhythms. Gastaut, Corriol, and Roger (1) were able to make some determinations from the visual cortex in subjects with unusually large responses to light flash, but their data suggest that they were measuring a secondary component of the evoked potential. Purpurá *et al.* (2) studied three patients, two schizophrenic, with brain exposed at operation; their results suggested delayed recovery to direct cortical stimulation in the schizophrenic. We applied Dawson's principle of averaging to extract evoked potentials from scalp recordings (3); in a few subjects we showed that the records so obtained could be used to plot a cortical reactivity cycle.

In the study reported here, cortical potentials evoked by electrical stimulation of the ulnar nerve at the wrist were extracted by means of a photographic averager. Shipton has described the apparatus (4). The electroencephalographic recording from the somatosensory area contralateral to the stimulus is led to a cathode ray oscilloscope, whose beam is modulated so that fluctuations of brightness in a horizontal line correspond to amplitude variations in the usual Y-axis. The vertical position of the beam is systematically shifted for each sweep by a raster. We photograph 100 sweeps routinely on Polaroid slide film. The film is optically analyzed by moving it across a slit through which a beam of light passes onto a photomultiplier, the output of which is written out on an X-Y plotter. Figure 1 shows a film and the corresponding tracing; it also indicates the difficulty of detecting evoked potentials in the electroencephalogram. Electrical stimuli were brief (usually 0.1 msec) and of sufficient intensity to elicit a twitch in the little finger. The time between successive pairs of stimuli was 1.3 seconds.

The film record in Fig. 1 demon-

strates that the primary evoked potential is consistently present and of constant latency. Upward deflection in the tracings indicates relative positivity at the active electrode. The primary complex begins with a negative deflection, maximal at latency of 17 to 23 msec; positivity follows, peaking at 21 to 30 msec. There may be two positive components in the complex. A more variable series of secondary components, extending to 350 or 400 msec, generally follows the primary complex.

Reactivity cycles were obtained in 13 apparently healthy nonpatients and in 92 psychiatric patients of all types. The cycles are based only on primary responses, measured from peak negativity to peak positivity. Mean amplitude was about 3 μ v. Pairs of stimuli were separated, from 2.5 to 200 msec, by 26 intervals, with separations in steps of 2.5 msec from 2.5 to 20 msec and in steps of 10 msec thereafter.

The tracings in Fig. 2 illustrate recovery of responsiveness for one subject with unusually large responses and very little secondary activity. Ordinarily the secondary components must be separated from the second primary re-

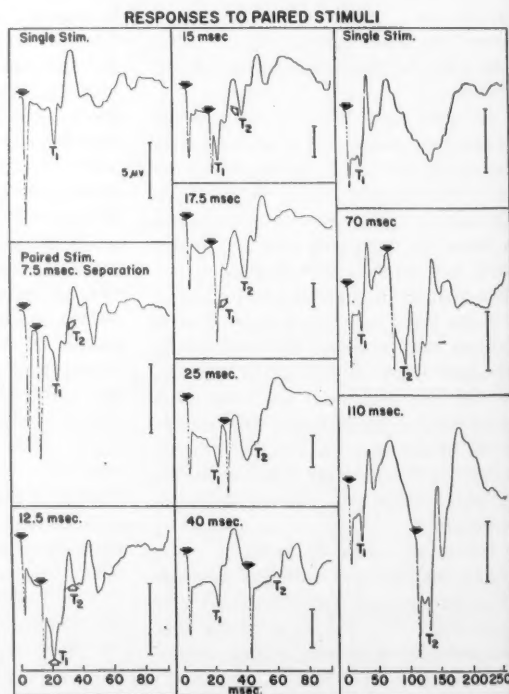
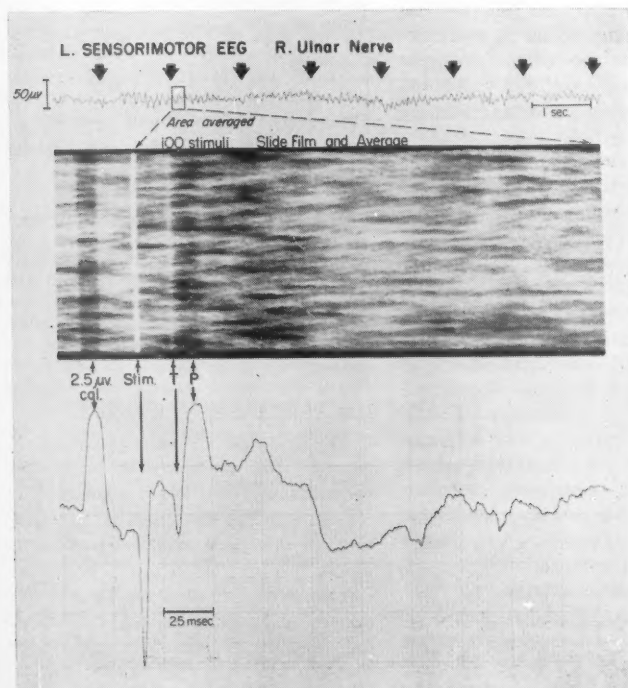


Fig. 1 (left). (Upper trace) Effect of single shocks to the right ulnar nerve on a conventional electroencephalogram from the left sensorimotor area. (Bottom trace) Optical analysis, giving an average of 100 responses from slide film (film and trace on identical time scale). *T*, Maximum initial negativity; *P*, peak of positive component. Fig. 2 (right). Tracings from one subject to illustrate development and amplitude fluctuation of responses to the second of a pair of stimuli separated by varying intervals. The time scale is longer in the right-hand column; *T*₁ and *T*₂, points of maximum negativity for the first and second responses.

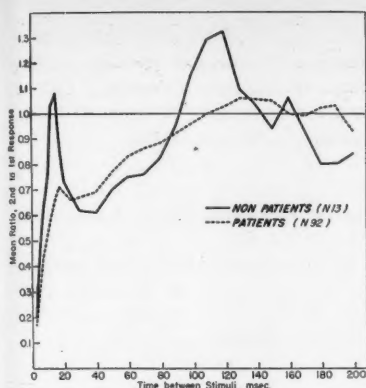


Fig. 3. Mean reactivity cycles of patients and nonpatients. A ratio of 1.0 indicates full recovery of responsiveness.

sponse by subtracting the changes at corresponding times subsequent to an unpaired stimulus. It may be noted in Fig. 2 that the second response increases until it is as large as the first at a separation of 17.5 msec. A subsequent brief period of response greater than normal is then followed by diminished responsiveness until the second response is again greater than the first, at 110 msec. This biphasic pattern characterized the recovery curves of all nonpatients, as indicated in the mean curve (Fig. 3).

Figure 3 also shows the mean reactivity cycle for the patients. Although the biphasic pattern was also the predominant one in the individual curves of most of the patients, this is not clear in the mean curve because the amount of recovery was less than in nonpatients and there was greater dispersion in timing. The greatest difference between patients and controls was in the amount of recovery by 20 msec. All nonpatients, except one with a peak recovery ratio of 0.95, showed full recovery by 20 msec. Only 27 patients (29 percent) showed full recovery—a highly significant difference ($P < .001$). It may be noted that two-thirds of the patients whose recovery ratios overlapped those of the controls were diagnosed as psychoneurotic, whereas for psychotics there was almost no overlap. The greater reactivity of nonpatients from 100 to 120 msec was also statistically significant ($P = .03$). Reliability, on retest, of the measure of peak recovery by 20 msec was 0.78 in 17 subjects. No significant age or sex differences were found.

The mean time for initial recovery of reactivity in the nonpatients was 12.5

msec. This is more rapid than the recovery time reported for any animal and suggests that initial recovery time may be phylogenetically determined. It is also of interest that the major differences between patients and nonpatients in cortical reactivity occurred during this early phase of recovery. The differences in findings for patients and for controls indicate that research designed to determine factors governing the cortical reactivity cycle may be of great importance to psychiatry. Information about the anatomical locus and neurohumoral mechanisms underlying the cycle may help to clarify the pathophysiology of disturbed behavior. As the reactivity cycle is easy to determine in animals, relevant experimentation with implanted electrodes, with drugs, and with surgery may readily be carried out (5).

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References and Notes

1. H. Gastaut, J. Corriol, A. Roger, *Rev. neurol.* **84**, 602 (1951).
2. D. P. Purpura, J. L. Pool, J. Ransohoff, M. J. Frumin, E. M. Housepian, *Electroencephalog. and Clin. Neurophysiol.* **9**, 453 (1957).
3. C. Shagass and M. Schwartz, *J. Neuropsychiat.* **2**, 262 (1961); G. D. Dawson, *Electroencephalog. and Clin. Neurophysiol.* **6**, 65 (1954).
4. H. W. Shipton, "Proc. Intern. Conf. Med. Electronics, 3rd Conf., London, 1960," in press.
5. This study was supported, in part, by a research grant (MY-2635) from the National Institute of Mental Health, U.S. Public Health Service.

21 July 1961

Choline Sulfate in Higher Plants

Abstract. Choline sulfate, the sulfate ester of choline, is widely distributed in plant species and tissues. It constitutes up to one-third of the labeled metabolic products of radiosulfate uptake by roots of sulfur-deficient corn, barley, and sunflower plants. This neutral, nonabsorbed zwitterion appears to be a useful reservoir for sulfur in plants.

O-Choline sulfate has previously been identified in mycelia and conidiospores of certain fungi (1), in a genus of lichens (2), and in a red alga (3). The analogous choline phosphate occurs in higher plants and is involved in phosphorus transport by the sap (4).

In this study (5) corn (*Zea mays*), barley (*Hordeum vulgare*), and sunflower (*Helianthus annuus*) were grown in water or in sand with either a complete Hoagland solution or one lack-

ing sulfate. The roots were cut at different times, allowed to take up radiosulfate during periods of several hours, and extracted with hot 80-percent ethanol. Two-dimensional paper chromatography (6) and autoradiography revealed a major radioactive product ($R_F = 0.89$ in phenol and water [100:40 wt./wt.]; $R_F = 0.37$ in *n*-butanol, propionic acid, and water [142:71:100 vol./vol.]). It was identified as choline sulfate by cochromatography with synthetic choline sulfate- S^{35} , by the identity of the hydrolysis rates of the natural product and synthetic choline sulfate- S^{35} (half-time for hydrolysis is 33 minutes in 1.0N HCl at 100°C), and by repeated cocrystallization with synthetic choline sulfate (7).

In order to ascertain that the formation of choline sulfate was not due to microorganisms associated with the plant roots, corn and barley were grown on agar under sterile conditions. Choline sulfate- S^{35} was formed as before.

Choline sulfate was the major labeled compound formed by roots of sulfur-deficient plants, constituting up to one-third of the incorporated S^{35} . In leaves of the deficient plants as well as in normal roots and leaves of all the higher plants examined, choline sulfate constituted 5 to 15 percent of all the soluble sulfur compounds.

The large amount of choline sulfate formed in roots of sulfur-deficient plants suggests its function as a major sulfur reservoir. Its neutral nature and high solubility in organic solvents suggest that it functions as an effective transport agent and that choline-containing membranes mediate in the transport mechanism.

PER NISSEN
A. A. BENSON

Department of Agricultural and Biological Chemistry, Pennsylvania State University, University Park

References and Notes

1. D. W. Woolley and W. H. Peterson, *J. Biol. Chem.* **122**, 213 (1937); B. Spencer and T. Harada, *Biochem. J.* **77**, 305 (1960); M. Itahashi, *J. Biochem. (Tokyo)* **50**, 52 (1961); I. Takebe, *J. Gen. Appl. Microbiol.* **6**, 83 (1960).
2. B. Lindberg, *Acta Chem. Scand.* **9**, 917 (1955).
3. —, *ibid.* **9**, 1323 (1955).
4. J. V. Maizel, A. A. Benson, N. E. Tolbert, *Plant Physiol.* **31**, 407 (1956).
5. This work was supported by the U.S. Atomic Energy Commission and the Pennsylvania Agricultural Experiment Station.
6. A. A. Benson, J. A. Bassham, M. Calvin, T. C. Goodale, V. A. Hans, W. Stepka, *J. Am. Chem. Soc.* **72**, 1710 (1950).
7. C. M. Stevens and P. Vohra, *ibid.* **77**, 4935 (1955).

9 August 1961

128th Annual Meeting: Program Summary

History and Philosophy of Science (L)

Program chairman: Norwood Russell Hanson, chairman, department of history and logic of science, Indiana University.

All eight sessions of the program of Section L are cosponsored by the American Philosophical Association and the Philosophy of Science Association.

Tuesday 26 December

Empiricism and the Status of Theories. Norwood Russell Hanson will preside. How to be a good empiricist, Paul K. Feyerabend. Discussants: George T. McClure and Wilfrid Sellars. Theoretical fruitfulness as a measure of concepts, Henry A. Finch. Discussants: Milik Capek and Ernest W. Adams.

Prediction and Causality. Wilfrid Sellars, Yale University, will preside. Reflexive predictions, Roger Buck. Discussants: Adolf Grünbaum and Michael Scriven. A workable concept of causation, Michael Scriven. Discussants: William H. Dray and William Rozeboom.

Wednesday 27 December

History and Philosophy of Science. Ernan McMullin, University of Notre Dame, will preside. Hypotheses in late medieval and early modern science, Edward Grant. Discussants: Giorgio de Santillana and Gerald Holton. Ethical problems within science, Nicholas Rescher. Discussants: Wolfgang Yourgrau and Robert S. Cohen.

Conventionalism and Laws within Modern Physics. David Hawkins, University of Colorado, will preside. Philosophical aspects of quantum field theory, A. E. Woodruff. Discussants: Satsi Watanabe and Hilary Putnam. Convention and the concept of state in physics, Richard A. Mould. Discussants: Joseph Epstein and Robert S. Cohen.

Thursday 28 December

Induction, and Vice Presidential Address. Wolfgang Yourgrau, chairman, department of history and methods of science, Smith College, will preside. A probabilistic view of formation of concept and of association, Satsi Watanabe. Discussant: Herbert Feigl. Vice presidential address of section L. Scientists and logicians: a confrontation, Norwood Russell Hanson, professor of philosophy, Indiana University; vice president of Section L.

Section L Luncheon. Arranged by David Hawkins, University of Colorado.

Second George Sarton Memorial Lecture. Sponsored by the George Sarton Memorial Foundation. Chauncey D. Leake, retiring president, AAAS, presiding. The international geophysical year, Joseph Kaplan, University of California, Los Angeles.

Friday 29 December

Machines and Brains. Herbert Feigl, director, Minnesota Center for Philosophy of Science and professor of philosophy, University of Minnesota, will preside. Brains and behavior, Hilary Putnam. Discussants: William Rozeboom and Newton Garver. Design for a mind, David Hawkins. Discussants: Bruce Aune and Peter Winch.

Methodological Problems of the Social Sciences. Kenneth R. Hammond, University of Colorado, will preside. Reduction of psychology to physiology? Herbert Feigl. Discussants: Roger Buck and Merle Turner. Some problems in the logic of sociological theory, Richard Rudner. Discussants: Benjamin Nelson and Grover Maxwell.

Saturday 30 December

The Nature of Historical Explanation. Adolf Grünbaum, University of Pittsburgh, will preside. The present

state of the Popper-Hempel thesis, Alan Donagan. Discussants: Benjamin Nelson and Nicholas Rescher. Causal judgment in history, William H. Dray. Discussant: Newton Garver.

American Philosophical Association

The American Philosophical Association is a cosponsor of the entire program of Section L—History and Philosophy of Science.

Philosophy of Science Association

Friday 29 December

Law, Science and Decision Making. Panel discussion. Joint program of the Philosophy of Science Association and the Institute of Management Sciences. Arranged by C. West Churchman, University of California, Berkeley. Lewis Zerby, Michigan State University, will preside. Panel members: Thomas Cowan, C. West Churchman, and Richard S. Rudner.

The Philosophy of Science Association is a cosponsor of the entire program of Section L—History and Philosophy of Science.

Society for General Systems Research

Friday 29 December

The Teaching of Systems Thinking. Symposium arranged by R. L. Meier, Mental Health Research Institute, University of Michigan, Ann Arbor, who will preside. Management games as instruments for teaching systems principles, James R. Jackson. Teaching through participation in microsimulations of social organization, Richard L. Meier. Use of simulation in the teaching of international systems, Chadwick F. Alger. Computer simulation of a community for farming, Nathan D. Grundstein.

Industrial Science (P)

Tuesday 26 December

Industrial Science Award Presentation. Allen T. Bonnell, vice president, Drexel Institute of Technology, will preside. Presentation of award by S. O. Morgan, Bell Telephone Laboratories, Murray Hill, New Jersey.

Wednesday 27 December

Luncheon Meeting and Vice Presidential Address. S. O. Morgan, presiding. Speaker, J. A. Hutcheson, vice president engineering, Westinghouse Electric Corporation; retiring vice president for Section P.

Section P is a cosponsor of the symposium of the Institute of Management Sciences.

Education (Q)

Tuesday 26 December

Joint Session of AAAS Section Q—Education and the Council for Exceptional Children, arranged by Louis A. Fiegler, University of Denver, who will preside. The realism of level of aspiration of mentally handicapped children, James Lent. A study of personality, value, and interest patterns of student teachers in the areas of elementary, secondary, and special education, Marion Phillipus and Louis A. Fiegler. An empiricist's approach to research with exceptional children, Joseph E. Spradlin. The dynamics of intellectualization with the gifted, Edwin Richardson. An investigation of the body image in secondary stutterers as revealed through self drawings, Joseph Fitzpatrick.

Wednesday 27 December

A second **Joint Session of AAAS Section Q—Education and the Council for Exceptional Children**, arranged by Louis A. Fiegler, University of Denver. Norris Haring, University of Kansas, will preside. An investigation of the Syracuse sociometric scale for assessing social needs of mentally retarded children, Barbara Edmonson. A study of the qualities and qualifications desired in teachers of the gifted, Alice Hayden. Problems of classroom adjustment of Indian children to public school classrooms in the Southwest, Miles Zintz. Recent research findings on creativity, Calvin Taylor.

Friday 29 December

Contributed Papers I, Vice Presidential Address, and Business Meeting, arranged by Herbert A. Smith, University of Kansas. H. Craig Sipe, George Peabody College, will preside. The application of discriminate function to problems in science education, Kenneth E. Anderson. Twelve yearly studies of televiewing, Paul Witty.

Vice Presidential Address of Section Q. Herbert A. Smith will preside. Imperatives of curriculum research and development, William H. Bristow, director, Bureau of Curriculum Research, Board of Education of the City of New York; vice president for Section Q.

Business Meeting of Section Q. William H. Bristow will preside.

The Shaping of a Scientist: Some Basic Theory, symposium arranged by Alice Y. Scates, research coordinator, cooperative research branch, U.S. Office of Education. Ralph Tyler, director, Institute for the Advanced Study of the Behavioral Sciences, Stanford, Calif., will preside. Student achievement in high school science courses, Victor Cline. The science aptitudes of high school students, John Dailey. Higher education for potential scientists and secondary school science teachers, Howard Gruber. Development of mathematical concepts in children, Patrick Suppes.

Saturday 30 December

Intervention in Personality Development of College Students Preparing To Teach, symposium. Joint program of AAAS Section Q—Education and the American Educational Research Association, arranged by Daniel D. Feder, San Francisco State College. David G. Ryans, System Development Corporation, Santa Monica, Calif., will preside. Introduction—overview of the mental health in teacher education demonstration, Robert F. Peck and Oliver H. Bown. Measurement of personality change during the college years, Robert F. Peck and Donald Veldman. Studies in attrition of students preparing to teach, Glenn E. Barnett. A model for planning and assessing intervention through instruction, J. Carson McGuire. Intervention through counseling with students and increasing faculty awareness of psychodynamics of students, Oliver H. Bown.

Contributed Papers II, arranged by Herbert A. Smith, University of Kansas. Joseph D. Novak, Purdue University, will preside.

Technology in Education, symposium. Joint program of AAAS Section Q—Education and the American Educational Research Association, arranged by Daniel D. Feder, San Francisco State College. Launor F. Carter, System Development Corporation, Santa Monica, Calif., will preside. The results of research on several variables in auto-

mated instruction, Harry Silberman. The Encyclopaedia Britannica Films studies in the use of self-instructional material, Allen Calvin. Educational television and the Midwest program of airborne television instruction, Leon Hibbs. Educational data processing, Murray Tondow. A system laboratory for the integrated study of the application of technology to education, Launor F. Carter.

Contributed Papers III, arranged by Herbert A. Smith. William H. Bristow, Board of Education, City of New York, will preside.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (Q1)

Wednesday 27 December

Studies in Teacher Education. Joint program of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, AAAS Section Q—Education, and the National Association for Research in Science Teaching, arranged by John R. Mayor, AAAS, who will preside. Certification of science teachers by examination, J. Charles Jones. Mathematics for elementary school teachers, college student teaching, and a new type of teacher examination, John A. Barlow. Report on the Hunter College practicum in science for elementary teachers, Archie Lacey.

Program notes for the other sections have appeared in previous issues of *Science*: "Chemistry" and "Mathematics and Related Programs," 27 October, page 1376; "Physics" and "Astronomy," 3 November, page 1438; "Agriculture" and "Geology and Geography," 10 November, page 1534; "Zoological Sciences," "Botanical Sciences," "Medical Sciences," "Dentistry," and "Pharmacy," 17 November, page 1630; and "Anthropology," "Psychology," and "Social and Economic Sciences," 24 November, page 1700.

On page 1720 of this issue appears a coupon which readers can mail in to obtain hotel reservations for the annual meeting.

Study of science following student teaching, W. Ware Marsden. The San Francisco State College Science Teaching Center project, Charles E. Burleson. A seminar for preservice teachers of science, Millard J. Seeley. A teaching laboratory, the new curriculum materials, and a liberal education, J. A. Easley, Jr. Some promising modifications in teacher education programs, W. W. Wyatt. By title only: role of problem solving in student teaching and related methods courses in mathematics and social studies, John A. Brown.

Elementary School Science, arranged by John R. Mayor, AAAS. Thomas S. Hall, department of zoology, Washington University, will preside. Reports on programs for the development of course content in elementary science. Speakers: J. A. Cooley, department of mathematics, University of Tennessee; Philip G. Johnson, Science Education Section, Cornell University; Robert Karplus, department of physics, University of California, Berkeley; and Stanley P. Wyatt, department of astronomy, University of Illinois.

Friday 29 December

Teaching Machines and Mathematics Programs: The Interaction of Content and Programing Specialists in Developing Self-Instructional Programs, symposium. Joint program of AAAS Cooperative Committee on the Teaching of Science and Mathematics and AAAS Sections A—Mathematics and I—Psychology, arranged by Joseph Hammock, Bell Telephone Laboratories, Murray Hill, N.J., and John R. Mayor, AAAS. Joseph Hammock will preside. Speakers: Lewis D. Eigen, Center for Programed Instruction, New York, N.Y.; John A. Barlow, Emory University; Norman A. Crowder, U.S. Industries, Inc., New York, N.Y.; Lloyd E. Homme, Teaching Machines, Inc., Albuquerque, N.M.; and Jack E. Forbes, Britannica Center for Studies in Learning and Motivation, Palo Alto, Calif. Discussants: Max Beberman, University of Illinois; R. Creighton Buck, University of Wisconsin; and Robert M. Gagné, Princeton University.

Science Service

Friday 29 December

Extracurricular Motivation for Science, arranged by Leslie Watkins, Science Clubs of America, Washington, D.C. Watson Davis, Science Service,

Washington, D.C., will preside. Student research projects, F. P. Venditti. Summer institute programs, R. B. Feagin. Student summer employment, Charles L. Bragaw. Extracurricular activities and the school program, Richard S. Peterson. Science teachers and club sponsors, science fair committee members, and Science Talent Search cooperators are especially invited to attend this session and participate in the discussion.

Science Teaching Societies Affiliated with AAAS

Coordinated Program of: National Association of Biology Teachers, National Association for Research in Science Teaching, National Science Teachers Association, and American Nature Study Society.

The science teaching societies affiliated with the AAAS first met jointly in Washington, D.C., in 1948, the year of the AAAS centennial, and have done so every year since then. The occasion serves as the annual meeting of ANSS and NABT, the annual symposium of NARST, and the winter regional meeting of NSTA. In addition to one or more joint general sessions, the coordinated program is designed to provide separate meetings for each society and other functions cosponsored by two or more of the societies.

Program Coordinator: Sam S. Blanc, coordinator of instruction, Denver Public Schools, Denver.

Wednesday 27 December

Molecular Biology, symposium, all science teaching societies; arranged by Alfred Novak, chairman, science and mathematics division, Stephens College, who will preside. Greetings and welcome, Kenneth E. Oberholtzer, superintendent, Denver Public Schools. Genetic architecture, Leonard Lerman. Molecular structure of proteins, Henry Borsook. Enzymes and their relation to the molecular architecture of the cell, Irwin W. Sizer. Discussion.

Studies in Teacher Education, AAAS Cooperative Committee and NARST, arranged by John R. Mayor, AAAS, who will preside.

Annual NABT Luncheon and Address. Paul Webster, president, NABT, will preside. The biology of nuclear war, Bentley Glass, chairman BSCS; Johns Hopkins University.

Elementary Science Session, all sci-

ence teaching societies; arranged by Sam S. Blanc, Gove Junior High School, Denver. James A. Bailey, supervisor of science, Denver Public Schools, will preside. Trends in elementary science teaching, Albert Piltz. Providing opportunities for the development of critical thinking abilities, Louise A. Neal.

Nature Study Around the World, American Nature Study Society. S. Glidden Baldwin, Danville, Ill.; president elect, ANSS, will preside. A naturalist explores Iran, John F. Wanamaker. Secondary school science teaching in Brazil, Paul Klinge. Introducing general science in Pakistan, Richard L. Weaver. World-wide interest in nature and conservation, Mrs. S. Glidden Baldwin.

Vistas in Earth Science, session I; National Science Teachers Association. Rodney F. Mansfield, consultant, science and mathematics, State of Colorado Department of Education, will preside. The chemist in oceanography, Norris W. Rakestraw, dean, graduate division, Scripps Institution of Oceanography. Panel: James R. Wailes, John Marean, and Donald W. Stotler.

Accent on Investigating, part I, NABT. Paul Webster, Bryan High School, Bryan, Ohio, president, NABT, will preside. A "new course"—individual investigation in biology, Paul F. Brandwein. An individual research approach, Flavin J. Arseneau. Individual and group approach to research, Stanley Roth. Discussion.

Elementary School Science. Program of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, arranged by John R. Mayor, AAAS.

Coffee Hour: Joint mixer. All science teaching societies.

Thursday 28 December

Outdoor Nature Interpretation. ANSS. Olaus J. Murie, director, the Wilderness Society, Moose, Wyo., will preside. Nature interpretation in the desert, W. H. Woodin. Grasslands natural history reservation, Ted F. Andrews. The role of national parks in the field of nature interpretation, Edwin C. Alberts. Guided versus self-guided activities in national parks nature interpretation, Wayne W. Bryant.

Accent on Investigating, part II: **New Teaching Opportunities**. NABT. Clarence J. Goodnight, Purdue University; first vice president, NABT, will preside. Programmed teaching in biology, Chester A. Lawson. Utilization of AIBS films

and the television course of Learning Resources Institute, John K. Bodel. Biology and team teaching, Robert H. Johnson.

Session II: Vistas in Science Facilities. NSTA. William W. Day, University High School, University of Wyoming, will preside. New trends in science facilities, Fred R. Schlessinger, director, second NSTA science facilities study, Department of Education, Ohio State University. Panel: Paul DeH. Hurd, Louise A. Neal, and Frank A. Anderson.

NABT Presidential Address. Muriel Beuschlein, Chicago Teachers College, Chicago, president elect, NABT, will preside. The biology teacher and his Association, Paul Webster, Bryan City Schools, Bryan, Ohio; president, NABT.

Conservation and International Resource Development, symposium; joint session of ANSS and NABT, arranged by Muriel Beuschlein, Chicago Teachers College, Chicago. Robert L. Smith; DeKalb High School, DeKalb, Ill.; third vice president, will preside. Conservation of resources of the Mediterranean area, Walter P. Taylor. Resource use in Pakistan, Richard L. Weaver. Conservation of natural resources in New Zealand, Frank O'Leary. Conservation and resource use in Thailand, Robert C. Leestma. Summary, S. Glidden Baldwin.

Accent on Investigating, part III: The Revised Versions of the Biological Sciences Curriculum Study. Brother G. Nicholas, Notre Dame University; second vice president, NABT, will preside. BSCS green version—team I: Gerald Tague and Thomas R. Mummey. BSCS yellow version—Team II: Eugene D. Gennaro and James F. Ragin. BSCS blue version—Team III: Frances W. Smith Jr., and Harry K. Wong.

Annual Showing of Kodachromes. John Wanamaker, Principia College, Elmhurst, Ill., will preside.

Friday 29 December

Joint Field Trip of ANSS and NABT. West field trip—covering the foothills, Front Range, Red Rocks Theatre and Genesee Mountains area, and geology and plant and animal life. Leaders: Donald M. Thatcher and David O. Davis. South field trip—covering the transition area between the mountains and Great Plains to the Garden of the Gods at Colorado Springs; geology and plant and animal life. Leaders: Paul W. Nesbit and Herbert I. Jones.

Session III: Vistas of Space Science.

Program of NSTA, cosponsored by the National Aeronautics and Space Administration. Lavar L. Sorensen, science supervisor, Salt Lake City Schools, will preside. Modern space science, Nelson Spencer, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md. Teaching materials and techniques in space science, James V. Bernardo, assistant director, Office of Technical Information and Educational Programs, National Aeronautics and Space Administration, Washington, D.C.

Research Symposium. NARST, arranged by Miss Edith M. Selberg, Colorado State College. Herbert A. Smith, University of Kansas; president NARST, will preside. Educational implications of creative research findings, Calvin M. Taylor. Creativity in scientific research, Edward U. Condon.

Biology Film Showing. NABT. Richard Fox, Richwoods Community High Schools, Peoria Heights, Ill., will preside. Living biology film series and program. Roman Vishniac, New York.

The Catholic High School and the BSCS Curriculum. Sister Mary Gabrielle, O.S.F., principal, Holy Trinity High School, Hartford, Conn., will preside. Sister Mary Ivo, B.V.M., Reverend Joseph Mulroy, O.S.M., and Father Donald Chegar.

Annual Report to the Society and Business Meeting. American Nature Study Society.

Annual Banquet of the American Nature Study Society. Ruth E. Hopson, Portland Extension Center; president ANSS, will preside. Nature adventures around the world, S. Glidden Baldwin, president-elect, ANSS. A movie with sound by Mrs. Baldwin: A report on their recent eight-month wildlife survey.

Saturday 30 December

Natural History of the Rocky Mountains, symposium, NABT, arranged by Ruth E. Hopson, Portland Extension Center, Portland, Ore., who will preside. The physical evolution of the Rocky Mountains: Illustrated chalk talk, S. H. Knight. From plains to peak tops: The changing panorama of animal life, plant life, and scenery from the Colorado Plains to the high country, Richard G. Beidleman. The lure of nature in the mountains, Paul W. Nesbit. Animals in the freedom of the Rockies, Olaus J. Murie.

Accent on Investigating, part IV. NABT. Herman C. Kranzer, Temple University, secretary-treasurer, NABT,

will preside. Laboratory design for the teaching of experimental biology, Philip Fordyce. Promising practices with the gifted student, Jerome Metzner. Some new materials for teaching biology, H. Seymour Fowler. The training of secondary school biology teachers, Paul DeHart Hurd. Training in science of elementary school teachers, Dorothy C. Matala.

Session IV: Vistas of Science Curricula. NSTA. Joseph A. Struthers, vice-president, Colorado Science Teachers Association, Colorado Springs, will preside. The NSTA curriculum study plan, Donald G. Decker, dean of the college, Colorado State College, Greeley. NSTA findings from film research program, Henry Angelino, College of Education, University of Oklahoma.

Session V: Colorado Science Teachers Association Luncheon. NSTA. Joseph Pierce, president, Colorado Science Teachers Association, Durango, Colo., will preside. Teaching moments, J. Darrell Barnard, New York University; president, NSTA.

Museum School Service and Displays. Joint session of ANSS and NABT, arranged by Alfred M. Bailey, director, Denver Museum of Natural History, who will preside. Museum School Service and the Planetarium, Robert E. Samples. Preparation of museum displays. The evolution of life series, Armita P. Neal. The habitat group, Alfred M. Bailey. Background work, William H. Traher. Foreground building, Robert R. Wright. Preparation of specimens, Henry C. Wichers. Field work: expedition film (Galapagos Islands). Museum tour.

Science in General (X)

Academy Conference

Wednesday 27 December

Breakfast Meeting of the Executive Committee.

Business Meeting and Discussion of Activities. Robert C. Miller, California Academy of Sciences; president, Academy Conference, will preside.

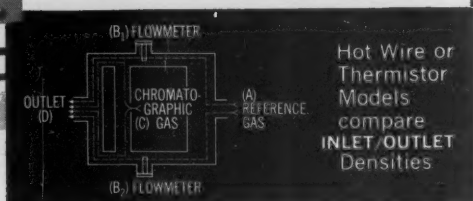
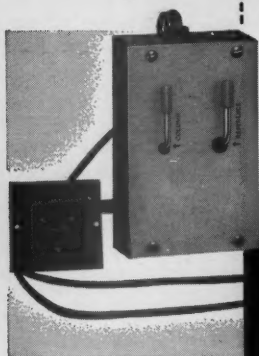
Debate Discussion: Why Collegiate Academies? E. Ruffin Jones, president elect, Academy Conference, will preside. Debaters: Norman D. Levine and Clinton L. Baker. Discussants: Charles M. Allen, Amy Le Vesconte, L. R. Edmunds, and R. S. Kiser.

Academy Conference Dinner and Presidential Address. John G. Arnold, Jr., retiring president, Academy Con-

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ference; will preside. Academies of science as catalytic agents, Robert C. Miller, director, California Academy of Science; president, Academy Conference.

Thursday 28 December

Session on Junior Academies. Gerald Acker, Bowling Green State University, will preside. Report on standing committee on junior academies. Regional high school science conferences, Myron S. McCay. Scientific papers by high school students, Lincoln Pettit. A national junior academy, pro and con, Elnore Stoldt.

Conference on Scientific Communication (X5)

The Conference on Scientific Communication has been a recurrent part of the annual meeting of the AAAS since 1952. The original purpose of the Conference was to bring before the Association some of the important problems that confront those who prepare scientific manuscripts. Subsequently, the scope was expanded to provide a forum where members or organizations concerned with all media for communicating scientific knowledge could meet to discuss mutual problems and to interchange ideas.

Those who have conducted the Conference on Scientific Communication at AAAS meetings for the past 10 years would welcome the establishment of a new AAAS section devoted to information and communication, though it would eliminate the need for a continuation of the Conference. It is anticipated that the spirit of the Conference would pass over into the new section and that all who have supported the Conference would support the new section.

Saturday 30 December

Luncheon for those interested in communication.

"Inauguration Session of New Section" (applicable if the AAAS Council votes approval of the new section), arranged by Chauncey D. Leake, Ohio State University; chairman, AAAS board of directors, who will preside. Introduction by the chairman. The scientific explosion, a puff or a bang, and what shall we do about it? Phyllis Parkinson. The collecting, storage, and retrieval of scientific information, Ralph R. Shaw. Indexing in depth, Isaac Welt. Solving the problems of interdisciplinary

nary communication in science, Foster E. Mohrhardt. The status of reviews in interdisciplinary communication, George L. Seielstad. Panel I: Interdisciplinary science communication. Panel members: Dale Baker, Miles Conrad, Graham DuShane, Eugene Garfield, Richard Orr, and Charles Shilling. Panel II: Communicating science to the people. Panel members: Victor Cohn, Watson Davis, Hillier Kriehbaum, Edward G. Sherburne, Jr., and John Sherrod.

Conference on Scientific Manpower

The Conference on Scientific Manpower has met during the annual meetings of the American Association for the Advancement of Science since the 118th meeting at Philadelphia in 1951. Its objective is the recognition and consideration of problems involving scientific manpower in the fields of physical, biological, engineering, and social sciences.

Wednesday 27 December

Invited Address. Program of the Conference on Scientific Manpower, co-sponsored by the Engineering Manpower Commission, Scientific Manpower Commission, National Research Council, National Science Foundation, and AAAS Sections E-Geology and Geography and M-Engineering. Howard A. Meyerhoff, Scientific Manpower Commission, will preside. Engineering and science—a struggle for survival? Truman H. Kuhn, dean of faculty, Colorado School of Mines.

National Association of Science Writers

Wednesday 27 December

Business Meeting. Victor Cohn will preside.

Reception, by invitation.

Annual Dinner and Announcement of AAAS-Westinghouse Science Writing Awards. Victor Cohn will preside.

Scientific Research Society of America

Friday 29 December

Annual Convention of the Scientific Research Society of America.

Joint Luncheon of the Society of the Sigma Xi and the Scientific Research Society of America and Annual Ad-

dress of the Scientific Research Society of America. W. J. Coppoc, presiding. Award of William Procter prize by W. J. Coppoc. Cooperation—a responsibility of the scientist, Edward R. Weidlein, former director, Mellon Institute, Pittsburgh.

Sigma Delta Epsilon Graduate Women's Science Fraternity

Thursday 28 December

Tea for All Women in Science. Ernestine B. Thurman, National Institutes of Health, will preside.

Society of the Sigma Xi

Friday 29 December

Joint Luncheon of the Society of the Sigma Xi and the Scientific Research Society of America.

Sixty-second Annual Convention of the Society of the Sigma Xi. Wallace R. Brode will preside.

Joint Address of the Society of the Sigma Xi and the United Chapters of Phi Beta Kappa. William W. Rubey, member, AAAS Board of Directors, will preside. Science and government, Harrison Brown, professor of geochemistry, California Institute of Technology.

Wilderness Society, Wildlife Management Institute, and Wildlife Society

These societies are cosponsors of Section O's symposium, Land and Water Use.

Forthcoming Events

December

12-15. American Soc. of Agricultural Engineers, Chicago Ill. (J. L. Burt, ASAE, 420 Main St., St. Joseph Mich.)

13. American Acad. of Arts and Sciences, Brookline, Mass. (J. L. Oncley, 280 Newton St., Brookline 46)

15-16. Modern Trends in Activation Analysis, College Station, Tex. (R. E. Wainardi, Activation Analysis Research Laboratory, Texas A. and M. College, College Station)

15-16. Oklahoma Acad. of Science, Stillwater. (D. Buck, Northern Oklahoma Junior College, Tonkawa)

17-18. International Congr. of Comparative Pathology, 9th, Paris, France. (L. Grollet, Comité International Permanent des Congrès de Pathologie Comparée, 63 Avenue de Villiers, Paris 17°)

19-23. Inter-American Congr. of Psy-

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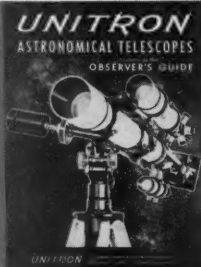
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chology, 7th, Monterrey, Mexico. (G. M. Gilbert, Psychology Dept., Long Island Univ., Brooklyn 1, N.Y.)

22-29. Plant Tissue and Organ Culture, intern. symp., New Delhi, India. (P. Maheshwari, Univ. of Delhi, Delhi)

26-28. History of Science Soc., annual, Washington, D.C. (J. C. Greene, 1121 Iowa Ave., Ames, Iowa)

26-31. American Assoc. for the Advancement of Science, annual, Denver, Colo. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5)

The following 45 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (J. R. Mayor, AAAS, 1515 Massachusetts Ave., NW, Washington, D.C.). 27 Dec.

AAAS Southwestern and Rocky Mountain Division (M. G. Anderson, New Mexico State Univ., University Park). 26-30 Dec.

Academy Conf. (J. G. Arnold, Jr., Loyola Univ., New Orleans, La.). 27-28 Dec.

Alpha Epsilon Delta (N. F. Witt, Univ. of Colorado, Boulder). 28-29 Dec.

American Astronautical Soc. (M. Pitkin, Martin-Denver, Denver, Colo.). 28-29 Dec.

American Astronomical Soc. (H. J. Smith, Yale Observatory, 135 Prospect St., New Haven, Conn.). 26-30 Dec.

American Economic Assoc. (K. E. Boulding, Univ. of Michigan, Ann Arbor). 26 Dec.

American Educational Research Assoc. (D. D. Feder, San Francisco State College, San Francisco, Calif.). 30 Dec.

American Nature Study Soc. (S. G. Baldwin, Danville, Ill.). 27-30 Dec.

American Physiological Soc. (R. E. Smith, Univ. of California, Los Angeles). 29 Dec.

American Political Science Assoc. (J. Korbel, Social Science Foundation, Univ. of Denver, Denver, Colo.). 27 Dec.

American Psychiatric Assoc. (D. A. Hamburg, Stanford Medical Center, Palo Alto, Calif.). 27 Dec.

American Soc. of Criminology (G. H. Barker, Dept. of Sociology, Univ. of Colorado, Boulder). 29-30 Dec.

American Soc. of Naturalists (E. W. Caspari, Univ. of Rochester, Rochester, N.Y.). 27 Dec.

American Soc. of Zoologists (R. L. Watterson, Univ. of Illinois, Urbana). 27-30 Dec.

American Sociological Assoc. (C. Taeuber, Bureau of the Census, Washington, D.C.). 29 Dec.

American Statistical Assoc. (J. A. Niederjohn, Ideal Cement Co., Denver, Colo.). 29-30 Dec.

Association of American Geographers (M. J. Loeffler, Univ. of Colorado, Denver). 26-28 Dec.

Association for Computing Machinery (W. F. Cahill, Goddard Space Flight Center, Greenbelt, Md.). 28 Dec.

Beta Beta Beta Biological Soc. (Mrs. F. G. Brooks, Box 515 Ansonia Station, New York 23). 26-27 Dec.

BIO (Biomedical Information-Processing Organization) (R. S. Ledley, Natl. Biomedical Research Foundation, Silver Spring, Md.). 27 Dec.

Biometric Society, WNAR (F. Graybill, Statistical Laboratory, Colorado State Univ., Fort Collins). 28 Dec.

Committee on Desert and Arid Zones Research, Southwestern and Rocky Mountain Div. of AAAS (T. L. Smiley, Univ. of Arizona, Tucson). 30 Dec.

Conference on Scientific Communication (C. D. Leake, Ohio State Univ., Columbus). 30 Dec.

Conference on Scientific Manpower (T. J. Mills, Natl. Science Foundation, Washington, D.C.). 27 Dec.

Ecological Soc. of America (R. S. Miller, Univ. of Saskatchewan, Saskatoon, Canada). 27-29 Dec.

Institute of Management Sciences (M. M. Flood, Mental Health Research Inst., Univ. of Michigan, Ann Arbor). 29 Dec.

Mathematical Assoc. of America, Committee on Undergraduate Program in Mathematics (R. J. Wisner, Michigan State Univ., Oakland, Rochester). 30 Dec.

Metric Assoc. (R. P. Fischelis, 502 Albee Bldg., NW, Washington, D.C.). 27-30 Dec.

National Assoc. of Biology Teachers (Miss M. Beuschlein, Chicago Teachers College, Chicago, Ill.). 27-30 Dec.

National Assoc. for Research in Science Teaching (Miss E. M. Selberg, Colorado State College, Greeley). 27-30 Dec.

National Assoc. of Science Writers (H. B. Nichols, U.S. Geological Survey, Washington, D.C.). 27 Dec.

National Geographic Soc. (R. Gray, National Geographic Soc., Washington, D.C.). 30 Dec.

National Science Teachers Assoc. (Miss M. Gardner, Natl. Science Teachers Assoc., Washington, D.C.). 27-30 Dec.

National Speleological Soc. (W. R. Halliday 1117 36 Ave., East, Seattle, Wash.). 29 Dec.

Philosophy of Science Assoc. (C. W. Churchman, Univ. of California, Berkeley). 29 Dec.

Scientific Research Soc. of America (D. B. Prentice, 51 Prospect St., New Haven, Conn.). 29 Dec.

Sigma Delta Epsilon (Miss E. B. Thurman (Natl. Institutes of Health, Bethesda, Md.). 28 Dec.

Society for General Systems Research (R. L. Meier, Mental Health Research Inst., Univ. of Michigan, Ann Arbor). 29 Dec.

Society for Industrial and Applied Mathematics (D. L. Thomsen, Jr., I.B.M. Corp., White Plains, N.Y.). 29 Dec.

Society of Protozoologists (N. D. Levine, College of Veterinary Medicine, Univ. of Illinois, Urbana). 27-30 Dec.

Society of the Sigma Xi (T. T. Holme, 51 Prospect St., Yale Univ., New Haven, Conn.). 29 Dec.

Society of Systematic Zoology (C. F. Lytle, Tulane Univ., New Orleans, La.). 27-30 Dec.

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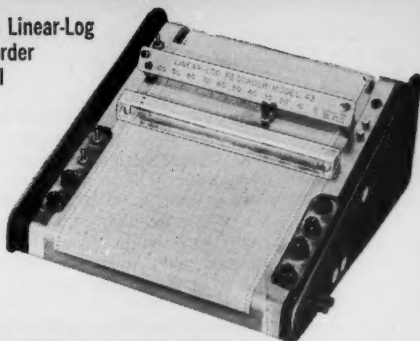
United Chapters of Phi Beta Kappa (C. Billman, 1811 Q St., NW, Washington 9). 29 Dec.

27-29. American Economic Assoc., New York, N.Y. (J. W. Bell, AEA, Northwestern Univ., Evanston, Ill.)

27-29. American Folklore Soc., Cincinnati, Ohio. (T. P. Coffin, 110 Bennett Hall,

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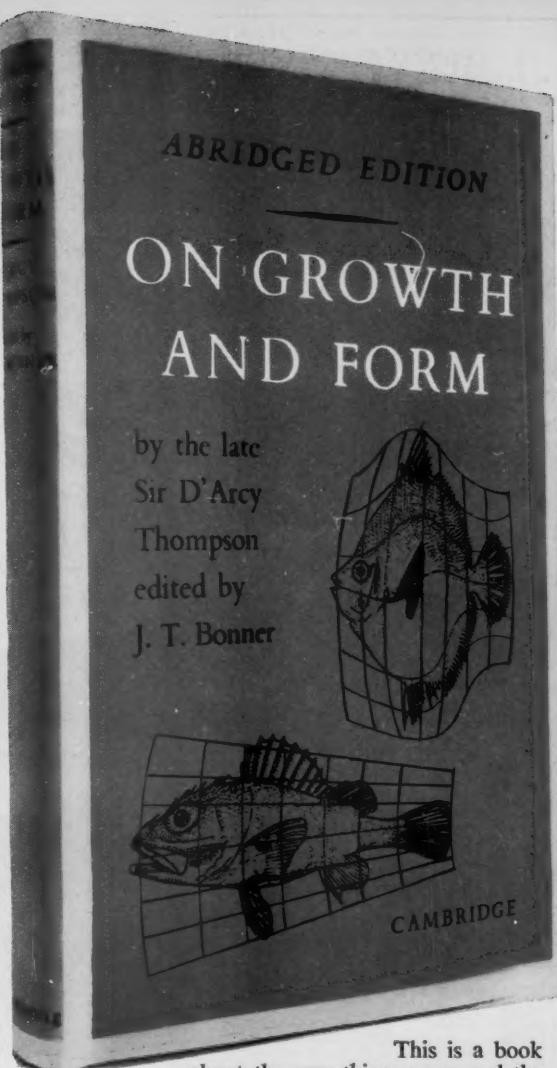
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Univ. of Pennsylvania, Philadelphia 4, Pa.)
27-29. American Geophysical Union, 1st western natl., Los Angeles, Calif. (A. N. Sayre, U.S. Geological Survey, Washington 25)

27-29. American Physical Soc., Los Angeles, Calif. (K. K. Darrow, 538 W. 120 St., New York 27)

27-29. Western Soc. of Naturalists, Eugene, Ore. (I. A. Abbott, Hopkins Marine Station, Pacific Grove, Calif.)

27-30. Institute of Mathematical Statistics, annual, New York, N.Y. (D. C. Riley, American Statistical Assoc., 1757 K St., NW, Washington 6)

28-29. Northwest Scientific Assoc., Spokane, Wash. (E. J. Larrison, Univ. of Idaho, Moscow)

28-29. American Chemical Soc., Div. of Industrial and Engineering Chemistry, Newark, Del. (Scientific Liaison Office, Natl. Research Council, Sussex Dr., Ottawa, Canada)

28-29. Linguistic Soc. of America, annual, Chicago, Ill. (A. A. Hill, Box 7790 University Station, Austin 12, Texas)
28-30. Archaeological Inst. of America, Detroit, Mich. (L. A. Campbell, 5 Washington Square N., New York 3)

28-30. Phi Delta Kappa, Bloomington, Ind. (R. S. Merkel, Indiana Central College, Indianapolis 27)

January

2-3. California Assoc. of Chemistry Teachers, San Luis Obispo, Calif. (R. Major, 1736 N. Sierra Bonita Ave., Hollywood 46, Calif.)

8-12. International Heat Transfer Conf., Institution of Mechanical Engineers, London, England. (Secretary, IME, 1 Birdcage Walk, Westminster, London, S.W.1)

8-12. Society of Automotive Engineers, annual, Detroit, Mich. (R. W. Crory, SAE, 485 Lexington Ave., New York 17, N.Y.)

8-13. Central Treaty Organization, Role of Science in Natural Resources, Lahore, Pakistan. (Office of Intern. Conferences, Dept. of State, Washington 25)

9-11. Reliability and Quality Control, 8th natl. symp., Institute of Radio Engineers and American Inst. of Electrical Engineers, Washington D.C. (Scientific Liaison Office, Natl. Research Council, Sussex Dr., Ottawa, Ont., Canada)

9-12. Radioactive Isotopes in Clinical Medicine and Research, 2nd symp., Bad Gastein, Austria. (R. Höfer, Garnisonsgasse 13, Vienna IX, Austria)

9-19. Synoptic Meteorology Code Problems, World Meteorological Organization, Toronto, Ont., Canada. (WMO, 41 Avenue Giuseppe Motta, Geneva, Switzerland)

11. Role of Hormones in Protein Synthesis, Assoc. of Vitamin Chemists, Chicago, Ill. (H. S. Perdue, Abbott Laboratories, N. Chicago)

15-17. American Pomological Soc., Toronto, Canada. (G. M. Kessler, Dept. of Horticulture, Michigan State Univ., E. Lansing)

17-19. Instrument Soc. of America, winter conf. and exhibit, St. Louis, Mo. (W. H. Kushnick, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

18-31. Tropical Cyclones, inter-regional seminar, World Meteorological Organization, Tokyo, Japan. (WMO, 41 Avenue Giuseppe Motta, Geneva, Switzerland)

22. American Ethnological Soc., New York, N.Y. (N. F. S. Woodbury, Arizona State Museum, Univ. of Arizona, Tucson)

22-23. Symposium on Perspectives in Virology III, New York, N.Y. (M. Pollard, Univ. of Notre Dame, Notre Dame, Ind.)

22-24. Institute of the Aerospace Sciences, 30th annual, New York, N.Y. (IAS, 2 E. 64 St., New York 21)

22-26. American Mathematical Soc., annual, Cincinnati, Ohio. (AMS, 190 Hope St., Providence 6, R.I.)

23. Conference on Cardiac and Vascular Surgery, New York Heart Assoc., New York, N.Y. (R. Ober, NYHA, 10 Columbus Circle, New York 19)

23-25. American Soc. of Safety Engineers, Philadelphia, Pa. (A. C. Blackman, 5 N. Wabash Ave., Chicago 2, Ill.)

23-25. Obstetrics and Gynaecology, 2nd Asiatic congr., Calcutta, India. (S. Mitra, 4 Chowringhee Terrace, Calcutta 20)

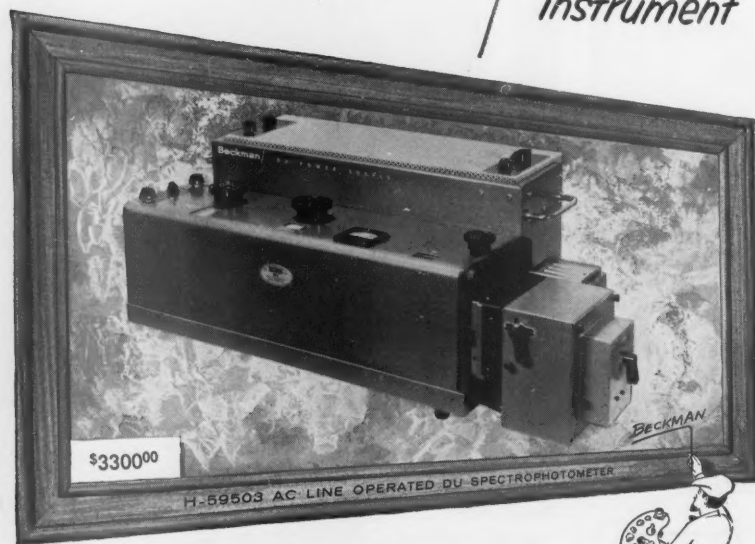
24-26. Mathematical Assoc. of America, 45th annual, Cincinnati, Ohio. (H. M. Gehman, Univ. of Buffalo, Buffalo, N.Y.)

24-26. Thermophysical Properties, symp., American Soc. of Mechanical Engineers, Princeton, N.J. (E. F. Lytle, ASME, c/o Thompson Ramo Wooldridge, 23555 Euclid Ave., Cleveland, Ohio)

24-27. American Physical Soc., annual, New York, N.Y. (K. K. Darrow, 538 W. 120 St., New York 27)

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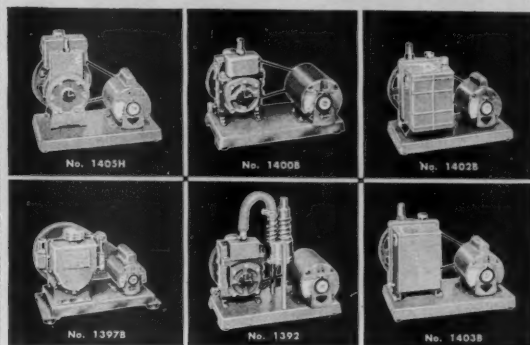
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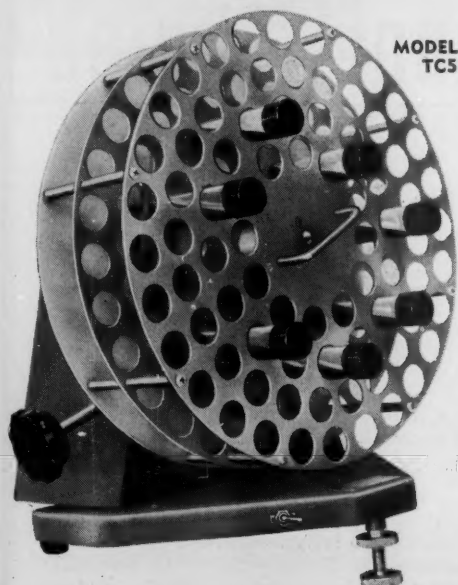
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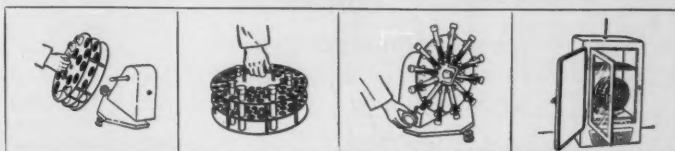
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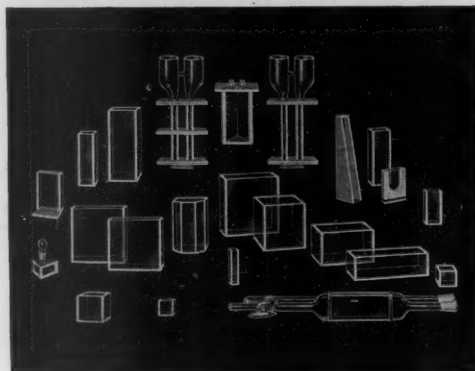
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PHYSICAL CHEMIST. Ph.D., with less than 5 years' experience. Qualified applicant will be able to solve theoretical, applied, and laboratory problems in gas dynamics, thermodynamics, chemical kinetics, and high temperature chemical equilibrium, and will be a U.S. citizen.

BIOCHEMIST. Ph.D., with less than 5 years' experience. Qualified applicant will be able to solve theoretical, applied, and laboratory problems in biochemistry, biology, microbiology, and organic chemistry, and will be a U.S. citizen.

These positions both provide excellent opportunities for professional growth in a new and rapidly growing research and development organization. Send résumé in confidence to Dr. J. B. Opfell, Dynamic Science Corporation, 1445 Huntington Drive, South Pasadena, California.

POSITIONS OPEN

Effective 1 January 1962

The rates for advertising in the Positions Open section of Science will be increased to \$50 per inch.

POSITIONS OPEN

RECENT Ph.D. or M.D.

—who wishes training in cardiovascular research methods. Salary \$6000 per year. Eastern medical school. Reply to

Box 221, SCIENCE

PHYSIOLOGIST— EXPERIMENTAL SURGEON

Ph.D. or V.M.D. to assume newly created, interesting and challenging position in Research Division of one of America's foremost producers of medical products. Position requires a physiological background with interest and experience in experimental surgery for participation in development of surgical products. Excellent opportunities in a congenial, ultra-modern atmosphere in suburban New Jersey. Interested candidates may apply by sending résumé with salary requirements to: Personnel Department.

ETHICON, INC.

A Johnson and Johnson Co. Somerville, N. J.
Route 22
Equal Opportunity Employer

CLASSIFIED: Positions Wanted 25¢ per word, minimum charge \$4. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for ads must reach SCIENCE 2 weeks before issue date (Friday of every week).

DISPLAY: Positions Open. Rates listed below—no charge for Box Number. Rates net. No agency commission allowed for ads under 4 inches. No cash discount. Minimum ad: 1 inch. Ads over 1 inch will be billed to the nearest quarter inch. Frequency rate will apply to only repeat of same ad. No copy changes. Payment in advance is required except where satisfactory credit has been established.

Single insertion	\$40.00 per inch
4 times in 1 year	38.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:

Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Toxicologist-Pharmacologist-Medical Writer. B.S., male, 11 years of industrial pharmaceutical research including pharmacology, toxicology, radiation biology, and medical writing for purposes of publication, advertising, and New Drug Applications. Publications. Box 222, SCIENCE. 12/8

POSITIONS OPEN

Need **MEDICAL RESEARCH ASSISTANT** with master's degree in a biological science and experience or training in virology, serology, and tissue culture for respiratory virus disease project. Tuition-free courses after 1 year. Write Personnel,

University of Vermont
Burlington, Vermont

The **UNIVERSITY OF ALBERTA** invites applications for positions in the **Department of Mathematics** at the **Lecturer, Assistant Professor, and Associate Professor** level. Appointments may be made at either the Edmonton campus or the Calgary campus of the university.

Salaries for 1962-63 will be in the ranges: assistant professors, \$6000-\$8700; associate professors, \$9000-\$11,700; with no fixed range for lecturers. Appointments will date from 1 September 1962, with commencing salaries dependent on experience and qualifications. Annual increments are normally given for satisfactory service. A pension plan is in operation and a removal grant may be made for married appointees and for single persons coming from outside North America.

Applications, accompanied by (1) a recent photograph, (2) transcripts of university records, (3) curriculum vitae, and (4) the names of three persons from whom references can be obtained, should be forwarded to Professor M. Wyman, Mathematics Department, University of Alberta, Edmonton, Alberta. 12/1, 8, 15

SCIENTIST

Entomologist, Nematologist, or Biologist (B.S. or M.S.) with training and preferably experienced, for agricultural pesticides research.

Liberal employee benefit program.

Forward full resume to:
BUSINESS MANAGER

**The Squibb Institute
For Medical Research**

New Brunswick, New Jersey
An Equal Opportunity Employer

POSITIONS OPEN

MEDICAL WRITER

Leading ethical drug firm has immediate position for outstanding man with medical writing experience. Degree in Chemistry or biological sciences plus 3-5 years drug experience required. Prepare journal articles, brochures, and other material in consultation with medical staff. Growth potential.

Send Resume to:
Technical Recruiter

**WARNER-CHILCOTT
LABORATORIES**

Morris Plains, New Jersey

(a) **Virologist**, research and development laboratories; Southeast. (b) **Biophysicist**, clinical, familiar with instrumentation; eastern hospital; \$8000-\$10,000. (c) **Biochemist**, research in human nutrition and metabolism; \$10,000-\$14,000; East. (d) **Physical Chemist**, research in colloids; \$9000-\$11,000; midwestern firm. (e) **Medical Research Scientists**, pathology and etiology of respiratory diseases; \$7000-\$14,000; Midwest. Many other opportunities are available for scientists of varying disciplines at all levels. Please communicate: Science Division, **The Medical Bureau, Inc.**, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago 11, Illinois. X

POSITIONS OPEN

SENIOR RESEARCH PHARMACOLOGIST

Ph.D. (pharmacology or physiology) to be responsible for pharmacologic research program involving biologic evaluation of novel enzymes for possible medical use. Principal duties would include development and implementation of a comprehensive enzyme screening and evaluation program. Will report directly to the Director of Pharmacologic Research. Midwestern metropolitan location. Excellent community and research facilities. Reply to R. M. Gesler,

Baxter Laboratories, Inc.
Morton Grove, Ill.

TOXICOLOGIST OR BIOCHEMIST

With suitable background to organize and head toxicology section of active Medical Examiner's office. Research opportunity and possible medical school affiliation available. Salary \$9000-\$10,000 plus Civil Service benefits. Contact Robert M. Greendyke, M.D., Medical Examiner, County of Monroe, 70 Clarissa St., Rochester 14, N.Y.

SK WRITER- EDITOR

Pharmaceutical Firm

Our Research Division has an opening for an experienced writer capable of writing clear scientific articles. Creative, challenging assignments—merit increase salary program—broad benefit coverage. Send complete resume—state salary needs—in confidence to:

**Smith Kline & French
Laboratories**

c/o PERSONNEL DEPT.—30-B

15th & Spring Garden Sts.
Philadelphia 1, Pa.

An Equal Opportunity Employer

FELLOWSHIPS

Predocutorial and Postdoctoral Fellowships in Medical Physics. Opportunities are available to do graduate work in the basic medical sciences. Emphasis is on the fields of radiation biology, radiation physics, and the clinical use of radioisotopes. Fellowship support is offered for study programs leading to the M.S. and Ph.D. degrees in medical physics and also for postdoctoral research. Stipends vary with training and dependents. Write to Chairman, Department of Radiology, Medical Center, University of California, Los Angeles 24, California.

SCHOLARSHIPS

The **INSTITUTE FOR NORTHERN STUDIES** is offering for the 1962-63 academic session, four scholarships, and possibly more, for students of marked ability interested in research problems to do with Northern Canada. This work may be in any field of the biological, physical, or social sciences or the humanities and will be carried out under the supervision of a department of the University of Saskatchewan.

Applicants who have no postgraduate experience are eligible to apply for scholarships of the value of \$1800 for 12 months, and those with at least 1 year of postgraduate research training are eligible to apply for scholarships of the value of \$2200 for 12 months. Essential equipment and traveling expenses incurred while carrying out a research project will be looked after by the Institute.

The Institute will also consider meeting essential equipment and traveling expenses incurred by a graduate student who holds a scholarship from some other source.

Further information and application forms may be obtained from the Secretary, Institute for Northern Studies, University of Saskatchewan, Saskatoon. The application forms and supporting documents must be received not later than 1 February 1962.

METABOLIC RESEARCH POSTS

Emphasis on endocrinological research has stimulated the creation of two new positions in our Metabolic Department. Each offers an opportunity to the creative, energetic scientist to participate fully in laboratory programs aimed at the discovery and development of significant new pharmaceutical products.

ENDOCRINOLOGY SECTION HEAD

- ▶ Should possess Ph.D. or M.D. degree with strong background in basic medical sciences plus demonstrated interest and experience in the study of endocrine function and dysfunction.
- ▶ To direct basic and applied research programs and to supervise activities of several Ph.D.'s and their groups.

SENIOR LABORATORY SCIENTIST

- ▶ Should possess Ph.D. degree with broad training in physiology or basic medical sciences with special interest in relationship of biochemistry to bodily function.
- ▶ To conduct laboratory investigations of new chemical leads thought to be useful in correcting metabolic disorders.

Please send resume, including salary requirements, to —

Wallace R. Hall, Employment Manager

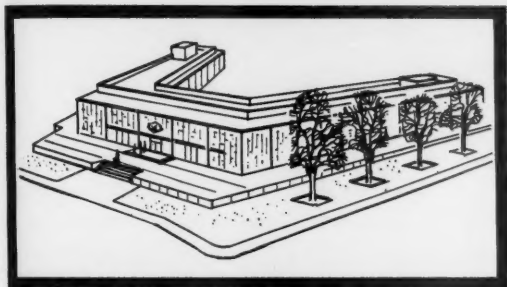


**SMITH KLINE & FRENCH
LABORATORIES**

1502 SPRING GARDEN STREET, PHILADELPHIA 1, PA.

An Equal Opportunity Employer

ADVANCING MAN'S KNOWLEDGE...



Miles Laboratories' recently-completed research center—an extension of present research facilities—will become the headquarters for our growing organization's expanding pharmaceutical research activities. Equipped with modern laboratory tools and designed to encourage interdisciplinary exchange of information and ideas, this new facility will provide an unusually fine research environment. Our competent professional staff is encouraged to apply creative research approaches in advancing man's knowledge in Biology, Biochemistry, Chemistry, Enzymology, Microbiology, Immunology, Pharmacology and Physiology. The company's continuing goal will be the development of pharmaceutical products by advancing the state of the art through creative research.

Inquiries may be directed in complete confidence to:

Dr. R. F. McCracken

Coordinator of Management Recruitment

(Personal discussions can be arranged at your convenience, including Saturdays, in Elkhart, Indiana)

**MILES LABORATORIES, INC.
and AMES COMPANY, INC.***

1127 Myrtle Street, Elkhart, Indiana

An Equal Opportunity Employer



If you are a qualified scientist and believe Miles Laboratories, Inc. may offer you a challenging position, you are invited to investigate these openings:

STAFF RESEARCH IMMUNOLOGIST

Will be responsible for staffing and leading a group of immunologists in a research program leading towards applications in the diagnosis and treatment of diseases. Must have a Ph.D. and/or M.D. degree plus several years' experience.

RESEARCH BIOCHEMIST

Principal responsibilities will involve conducting independent research programs for new enzyme products, to improve existing enzyme products and investigation of enzyme components, separation, purification, optimum performance, specificity studies and assay procedures. Must possess a Ph.D. in chemistry or biochemistry plus several years' experience in enzymological research.

RESEARCH CHEMIST

To define research objectives and programs and engage in basic and applied research. Should hold a Ph.D. in chemistry and several years' experience in organic synthesis, polymers, resins, and/or plasticizers.

RESEARCH INFORMATION SCIENTIST

Will work closely with laboratory chemists in collecting, evaluating, organizing and presenting scientific information pertinent to a current or proposed program having potential diagnostic or therapeutic interest. Must have Ph.D. in organic or medicinal chemistry or in a biological science. While previous science information experience is desirable, it is not a prerequisite.

ASSISTANT RESEARCH CHEMIST

Will perform various functions under guidance of research biochemist in enzyme analysis, isolation and screening. Must have a minimum of B.S. in chemistry and interest in biochemical, pharmaceutical or medical research.

ASSISTANT RESEARCH BIOCHEMIST

Will be responsible for carrying out clinical chemical investigations in connection with laboratory evaluations of new drugs. Should possess a B.S. in chemistry or biology plus experience as a medical technologist.

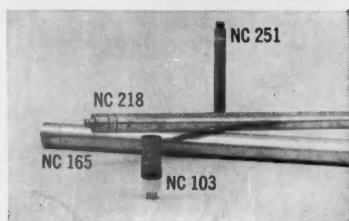
**Ames Company, Inc. is an ethical pharmaceutical division of Miles Laboratories, Inc.*

Our new Research Center is located in Elkhart, Indiana, a clean, progressive city of 40,000 people. In Elkhart, schools are among the best in the middle west and year 'round cultural and recreational activities for the whole family are only minutes from your door.



NUCLEAR REVIEWS

from
NUCLEAR-CHICAGO



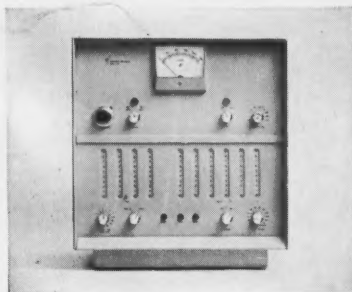
RADIATION DETECTORS ALL SIZES AND SHAPES

The greatly expanded radiation detector facility of Nuclear-Chicago designs and manufactures a wide selection of Geiger and BF_3 tubes. With many standard types and sizes to choose, the research scientist can usually obtain the right detector for his application without the cost of custom processing. Standard mica-end window tubes, cosmic ray detectors, halogen and organic quenched detector tubes, glass wall detectors, and liquid and gas flow detectors are all available. In addition, BF_3 gas proportional neutron detectors may be obtained in practically every size and shape. Their pressures range up to three atmospheres. All are sturdily constructed for long, rugged use.

Typical of the variety of tubes available from Nuclear-Chicago are the four tubes shown above. The NC 103 Proportional Detector represents a unique accomplishment among gas filled, thin end-window detectors because it can distinguish between alphas and betas. It is rated at more than 10^{10} counts without significant loss of resolution. NC 218 is a large cosmic ray neutron detector having a guard ring insulator which

assures low background. NC 251 is a general purpose thermal neutron detector with a ceramic insulator and stainless steel anode for high temperature operation. NC 165 is a sensitive cosmic ray meson detector for use in cosmic ray telescopes or in anticoincidence shields.

This representative sampling illustrates the extent to which our detector facility has progressed in providing the researcher with better radiation detectors. Write for further details on Nuclear-Chicago's quality detector line.



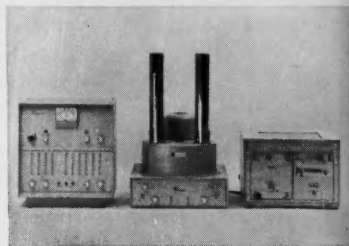
NEW AUTOMATIC DECADE SCALER

Outstanding developments in more glamorous areas of radioactivity measurement have overshadowed the workhorse of the isotope laboratory, the nuclear scaler. Rarely is a new scaler promoted in advertisements. And yet — the versatility of most counting systems is directly related to the design features of the scaling instrument.

Of the dozens of scalers available, Nuclear-Chicago's new 202 Decade Scaler pictured above is the finest complete scaler. It is a fully automatic instrument for use with all G-M, scintillation, or proportional detectors. Note these features: (1) a non-overloading linear amplifier with input sensitivity from 1 mv to 2 v controlled by fixed precision attenuators, (2) a resolution time of 1 microsecond, (3) six decades, (4) electronic timing to 100 minutes in increments of 0.01 minute, (5) both preset count and preset time control, (6) pushbutton electronic start, stop, and reset, (7) regulated low voltage power supply, and (8) regulated high voltage supply variable from 500 to 5000 volts in two ranges with a precision ten-turn control.

If you are considering an isotope laboratory or enlarging your present

facilities, you should investigate the 202 Scaler. We will be pleased to send full specifications.



NEW READOUT VERSATILITY FOR AUTOMATIC SAMPLE CHANGERS

An automatic sample changer is an investment which usually pays for itself in a short period of time. Day after day, it programs samples and collects digital or analog data for later use. However, an automatic sample changer is a poor investment if it is not combined with a readout system capable of providing all the needed data.

The 202 Decade Scaler (described above) and new 8400 Digital Recorder are an ideal combination for data readout. The digital recorder simultaneously prints sample index numbers with both time and count information. Once commanded to print by the scaler, the 8400 Recorder supplies reset and start commands to the automatic sample changer connected to it.

Thirteen predetermined time or thirteen predetermined count settings can be selected at the 202 Scaler. A time/count control is provided to command the 8400 Recorder to print when either the preset time or preset count is reached so that samples with low counting rates will not unnecessarily delay the counting cycle.

All Nuclear-Chicago automatic sample changers can be programmed with the 8400 Digital Recorder and 202 Decade Scaler. Detailed specifications on these instruments and on the complete Nuclear-Chicago line are contained in General Catalog S, available on request.



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